GENERAL PURPOSE, LOW VOLTAGE, RAIL-TO-RAIL OUTPUT OPERATIONAL AMPLIFIERS

Description

The LMV321/LMV358/LMV324 are low voltage (2.7V to 5.5V) single, dual and quad operational amplifiers. The LMV321/LMV358/LMV324 are designed to effectively reduce cost and space at low voltage levels.

These devices have the capability of rail-to-rail output swing and input common-mode voltage range includes ground. They can also achieve an efficient speed-to-power ratio, utilizing 1 MHz bandwidth and 1V/μs slew rate at a low supply current. Reducing noise pickup and increasing signal integrity can be achieved by placing the device close to the signal source.

The LMV321 is available in 5-Pin SOT353/SOT25 packages that reduce space on PC boards and portable electronic devices. The LMV324 is available in the SO-14 and TSSOP-14 package.

The LMV358 is available in the MSOP-8 and SO-8 packages.

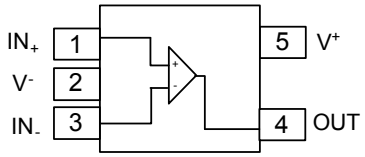
Features

(For V^+ = 5V and V^- = 0V typical unless otherwise noted)

- Guaranteed 2.7V and 5V Performance
- Crossover Distortion Eliminated
- Operating Temperature Range (-40°C to +125°C)
- Gain-bandwidth Product 1 MHz
- Low Supply Current
  - LMV321 110μA Typ
  - LMV358 190μA Typ
  - LMV324 340μA Typ
- Rail-to-Rail Output Swing @ 10kΩ
  - V^+ -10 mV
  - V^- +10 mV
- Input Common Mode Voltage Range (-0.2 to V^+ -0.8V)
- Manufactured in Standard CMOS Process
- SOT353, SOT25, MSOP-8, SO-8, SO-14 & TSSOP-14: Available in "Green" Molding Compound (No Br, Sb)
- **Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)**
- **Halogen and Antimony Free. "Green" Device (Note 3)**

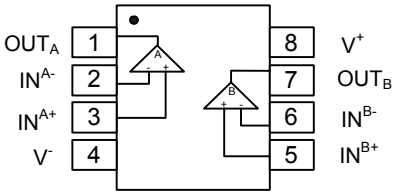
Pin Assignments

(Top View)



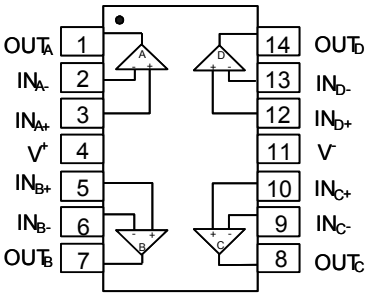
SOT25 / SOT353

(Top View)



SO-8 / MSOP-8

(Top View)



SOP-14L / TSSOP-14L

Applications

- Active Filters
- General Purpose Low Voltage Applications
- General Purpose Portable Devices

Notes:
1. No purposely added lead. Fully EU Directive 2002/95/EC (RoHS) & 2011/65/EU (RoHS 2) compliant.
2. See http://www.diodes.com for more information about Diodes Incorporated's definitions of Halogen- and Antimony-free, "Green" and Lead-free.
3. Halogen- and Antimony-free "Green" products are defined as those which contain <900ppm bromine, <900ppm chlorine (<1500ppm total Br + Cl) and <1000ppm antimony compounds.

Absolute Maximum Ratings (Note 4) (@T_A = +25°C, unless otherwise specified.)

Symbol	Parameter		Rating	Unit
ESD HBM	Human Body Model ESD Protection	LMV321	4.0	KV
		LMV358	4.0	
		LMV324	4.5	
ESD MM	Machine Model ESD Protection	LMV321	350	V
		LMV358	350	
		LMV324	250	
	Differential Input Voltage		±Supply Voltage	V
V^+ -V^-	Supply Voltage		5.5	V
	Output Short Circuit to V^+		(Note 5)	
	Output Short Circuit to V^-		(Note 6)	
T_{ST}	Storage Temperature		-65 to +150	°C
T_J	Maximum Junction Temperature		+150	°C

Notes: 4. Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is intended to be functional, but specific performance is not guaranteed. For guaranteed specifications and the test conditions, see the Electrical Characteristics.
5. Shorting output to V+ will adversely affect reliability.
6. Shorting output to V- will adversely affect reliability.

Recommended Operating Conditions (@T_A = +25°C, unless otherwise specified.)

Symbol	Parameter	Rating	Unit
V^+ -V^-	Supply Voltage	2.7 to 5.5	V
T_A	Operating Ambient Temperature Range	-40 to +125	°C

Electrical Characteristics (@T_A = +25°C, unless otherwise specified.)

2.7V DC Electrical Characteristics

Unless otherwise specified, all limits guaranteed for T_A = +25°C, V^+ = 2.7V, V^- = 0V, V_{CM} = 1.0V, V_O = V^+/2 and R_L > 1 MΩ.

Symbol	Parameter	Test Conditions	Min (Note 8)	Typ (Note 7)	Max (Note 8)	Unit
V_{OS}	Input Offset Voltage			1.7	7	mV
TCV_{OS}	Input Offset Voltage Average Drift			5		µV/°C
I_B	Input Bias Current			10		nA
I_{OS}	Input Offset Current			5	50	nA
CMRR	Common Mode Rejection Ratio	0V ≤ V_{CM} ≤ 1.7V	50	63		dB
PSRR	Power Supply Rejection Ratio	2.7V ≤ V^+ ≤ 5V, V_O = 1V	50	60		dB
V_{CMR}	Input Common-Mode Voltage Range	For CMRR ≥ 50dB	0	-0.2		V
				1.9	1.7	
V_O	Output Swing	R_L = 10 kΩ to 1.35V	V^+ - 100	V^+ - 20		mV
				20	100	
I_S	Supply Current	LMV321 Single amplifier		110	140	µA
		LMV358 Both amplifiers		190	340	µA
		LMV324 All four amplifiers		340	680	µA

2.7V AC Electrical Characteristics

Unless otherwise specified, all limits guaranteed for T_A = +25°C, V^+ = 2.7V, V^- = 0V, V_{CM} = 1.0V, V_O = V^+/2 and R_L > 1 MΩ.

GBWP	Gain-Bandwidth Product	C_L = 200 pF		1		MHz
Φm	Phase Margin			60		Deg
Gm	Gain Margin			10		dB
e_n	Input-Referred Voltage Noise	f > 50 kHz		23		$\frac{nV}{\sqrt{Hz}}$

Electrical Characteristics (cont.) (@T_A = +25°C, unless otherwise specified.)

5V DC Electrical Characteristics

Unless otherwise specified, all limits guaranteed for T_A = +25°C, V^+ = 5V, V^- = 0V, V_{CM} = 2.0V, V_O = V^+/2 and R_L > 1 MΩ.

Symbol	Parameter	Test Conditions			Min (Note 8)	Typ (Note 7)	Max (Note 8)	Unit
V_{OS}	Input Offset Voltage	T_A = +25°C				1.7	7	mV
		T_A = full range					9	
TCV_{OS}	Input Offset Voltage Average Drift					5		µV/°C
I_B	Input Bias Current	T_A = +25°C				15	250	nA
		T_A = full range					500	
I_{OS}	Input Offset Current	T_A = +25°C				5	50	nA
		T_A = full range					150	
CMRR	Common Mode Rejection Ratio	0V ≤ V_{CM} ≤ 4.0V			50	65		dB
PSRR	Power Supply Rejection Ratio	2.7V ≤ V^+ ≤ 5V V_O = 1V, V_{CM} = 1V			50	60		dB
V_{CMR}	Input Common-Mode Voltage Range	For CMRR ≥ 50dB			0	-0.2		V
						4.2	4.0	
A_V	Large Signal Voltage Gain	R_L = 2 kΩ (Note 9)	T_A = +25°C		15	100		V/mV
			T_A = full range		10			
V_O	Output Swing	R_L = 2 kΩ to 2.5V	High level	T_A = +25°C	V^+ - 300	V^+ -50		mV
				T_A = full range	V^+ - 400			
			Low level	T_A = +25°C		50	300	
				T_A = full range			400	
		R_L = 10 kΩ to 2.5V	High level	T_A = +25°C	V^+ - 100	V^+ -10		
				T_A = full range	V^+ - 200			
			Low level	T_A = +25°C		10	180	
				T_A = full range			280	
I_O	Output Short Circuit Current	Sourcing, V_O = 0V			5	60		mA
		Sinking, V_O = 5V			10	90		
I_S	Supply Current	LMV321 Single amplifier				110	140	µA
		LMV358 Both amplifiers		T_A = +25°C		190	340	
				T_A = full range			600	
		LMV324 All four amplifiers		T_A = +25°C		340	680	
				T_A = full range			1100	
θ_{JA}	Thermal Resistance Junction-to-Ambient	SOT353 (Note 10)				330		°C/W
		SOT25 (Note 10)				250		
		TSSOP-14 (Note 10)				100		
		MSOP-8 (Note 10)				203		
		SO-8 (Note 10)				150		
		SO-14 (Note 10)				83		

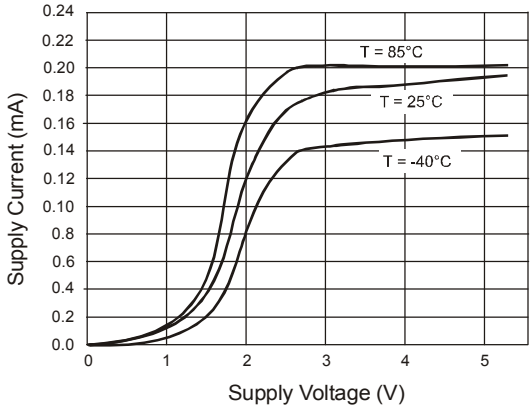
5V AC Electrical Characteristics

Unless otherwise specified, all limits guaranteed for T_A = 25°C, V^+ = 5V, V^- = 0V, V_{CM} = 2.0V, VO = V^+/2 and R_L > 1 MΩ.
Boldface limits apply at the temperature extremes.

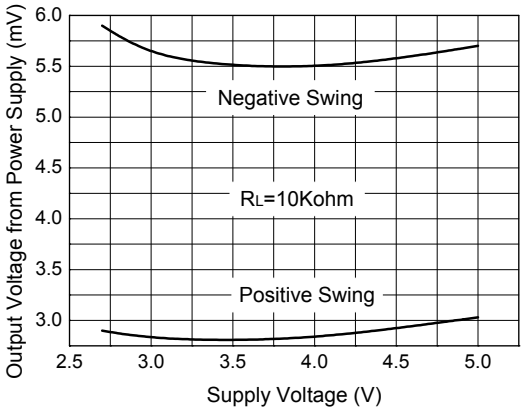
SR	Slew Rate	(Note 11)		1		V/µs
GBWP	Gain-Bandwidth Product	C_L = 200pF		1		MHz
Φ_m	Phase Margin			60		Deg
G_m	Gain Margin			10		dB
e_n	Input-Referred Voltage Noise	f > 50 kHz		23		$\frac{nV}{\sqrt{Hz}}$

Notes:
7. Typical values represent the most likely parametric norm as determined at the time of characterization. Actual typical values may vary over time and will also depend on the application and configuration. The typical values are not tested and are not guaranteed on shipped production material.
8. All limits are guaranteed by testing or statistical analysis.
9. R_L is connected to V-. The output voltage is 0.5V ≤ V_O ≤ 4.5V.
10. All numbers are typical, and apply for packages soldered directly onto a PC board in still air.
11. Connected as voltage follower with 3V step input. Number specified is the slower of the positive and negative slew rates.

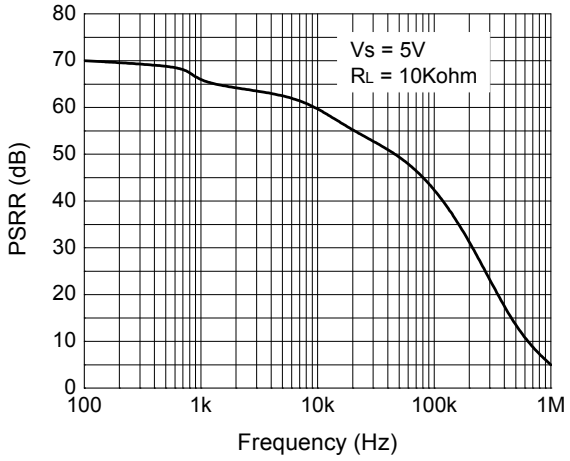
Typical Performance Characteristics (V_S = +5V, single supply, @T_A = +25°C, unless otherwise specified.)



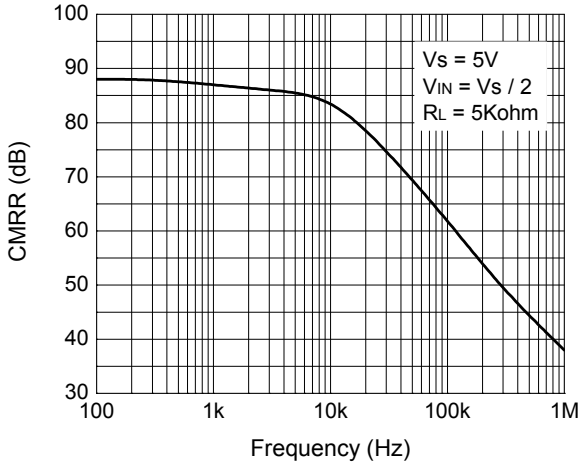
Supply Current vs. Supply Voltage



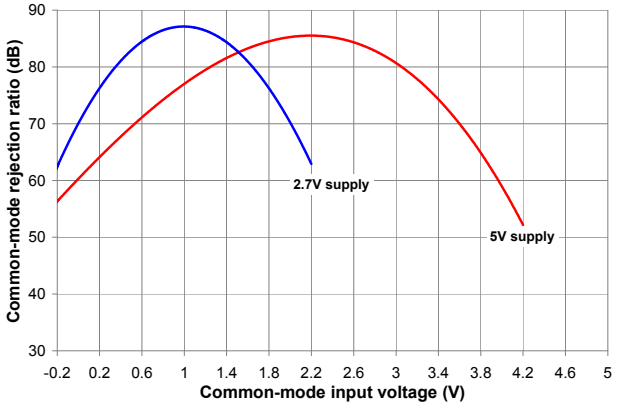
Output Voltage Swing vs. Supply Voltage



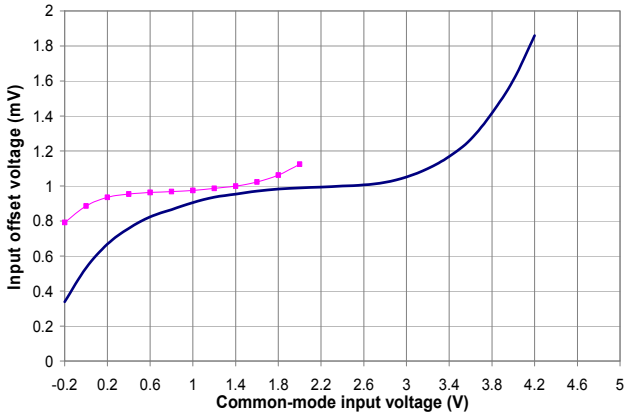
PSRR vs. Frequency



CMRR vs. Frequency

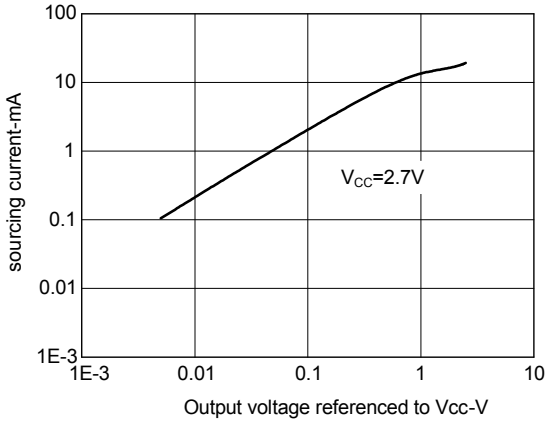


CMRR vs. Input Common Mode Voltage

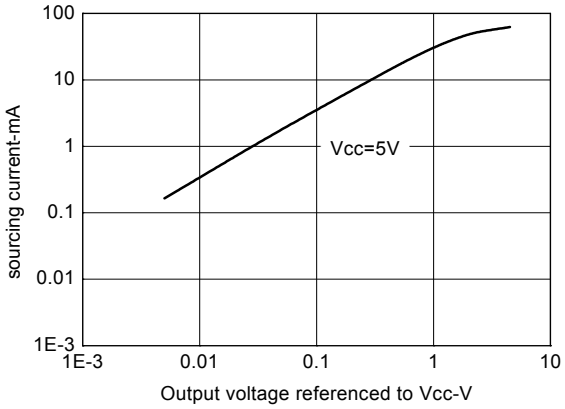


ΔVos vs. CMR

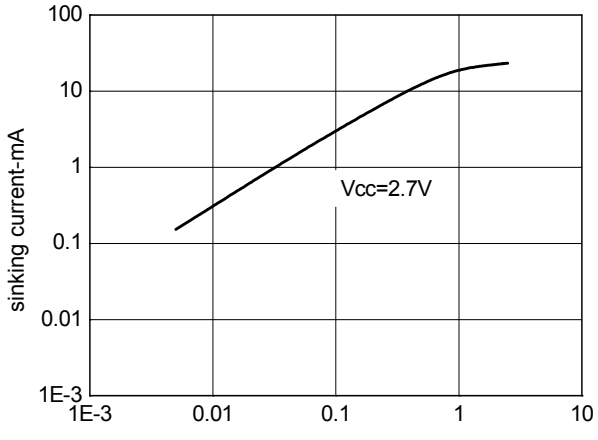
Typical Performance Characteristics (cont.)



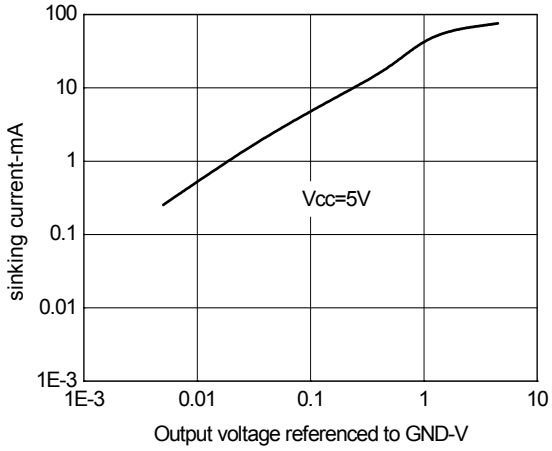
Sourcing Current vs. Output Voltage (2.7V)



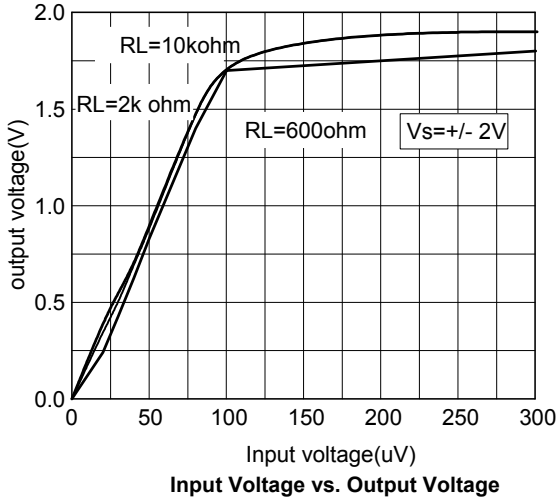
Sourcing Current vs. Output Voltage (5V)



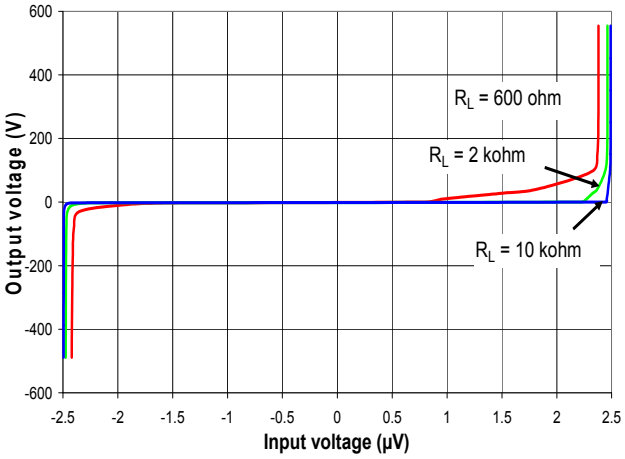
Sinking Current vs. Output Voltage (2.7V)



Sinking Current vs. Output Voltage (5V)

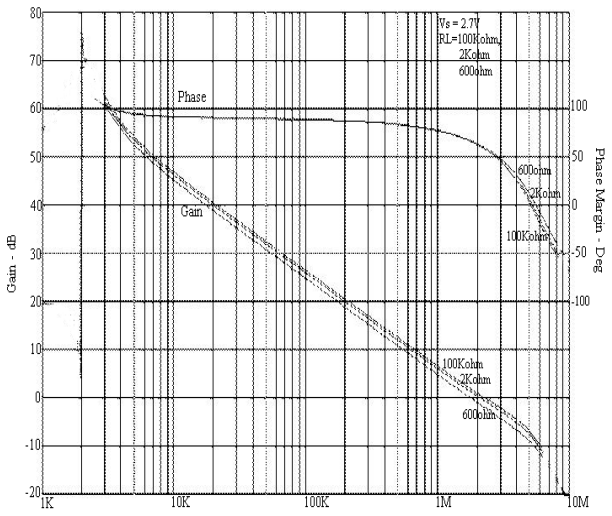


Input Voltage vs. Output Voltage

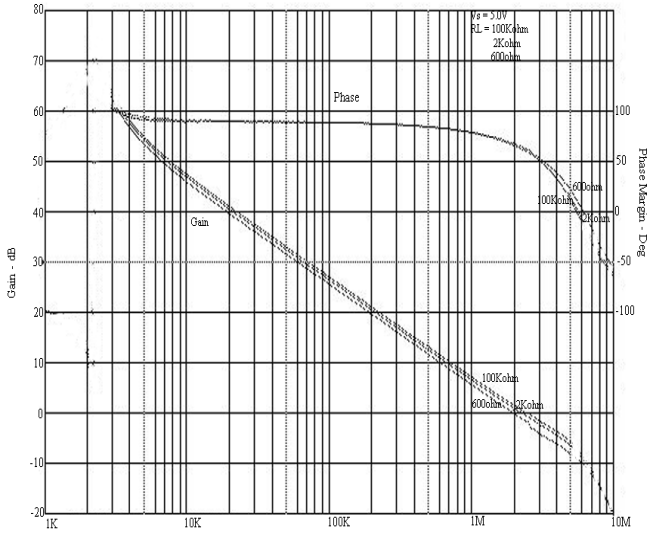


Output Voltage vs. Input Voltage

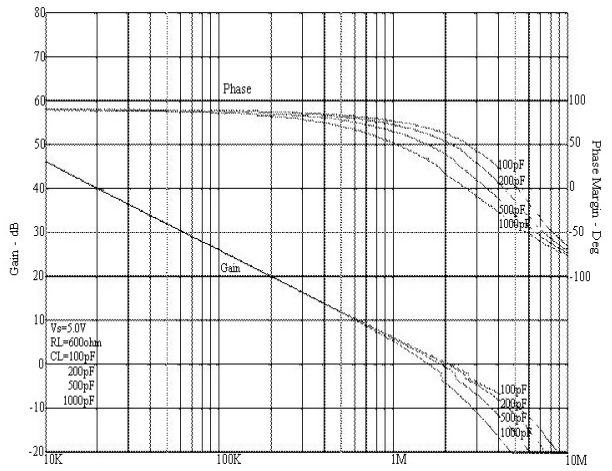
Typical Performance Characteristics (cont.)



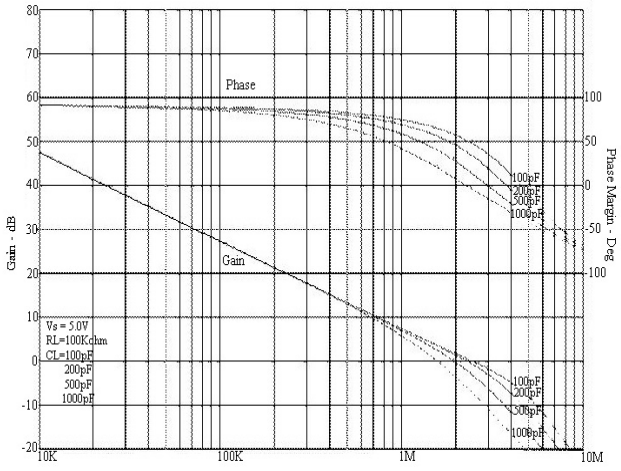
Frequency Response vs. Resistive Load (2.7V)



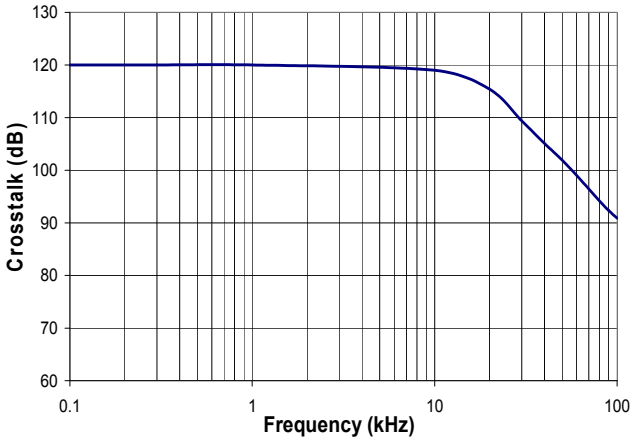
Frequency Response vs. Resistive Load (5V)



Frequency Response vs. Capacitive Load (2.7V)

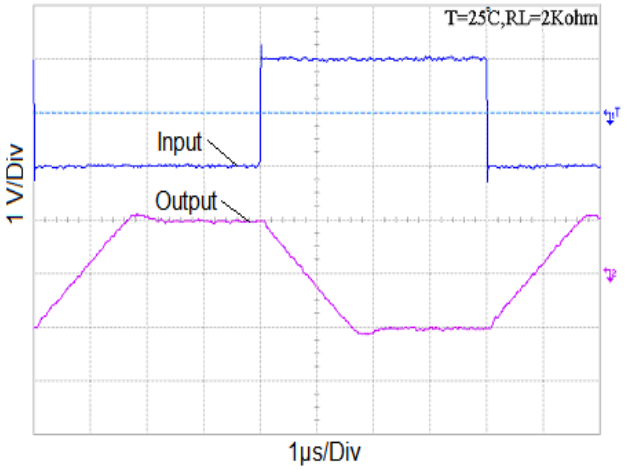


Frequency Response vs. Capacitive Load (5V)

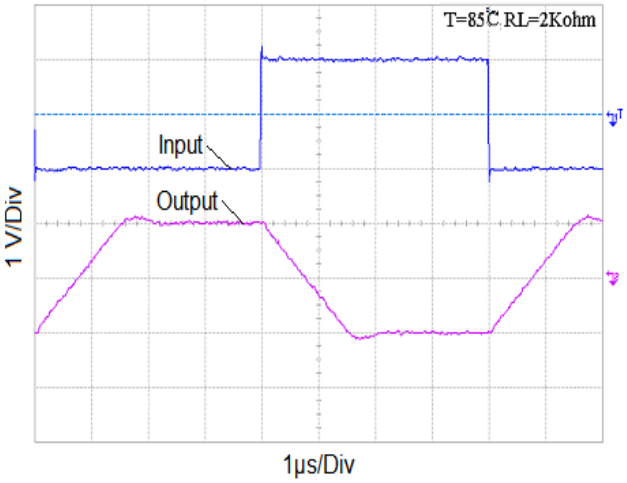


Crosstalk vs. Frequency

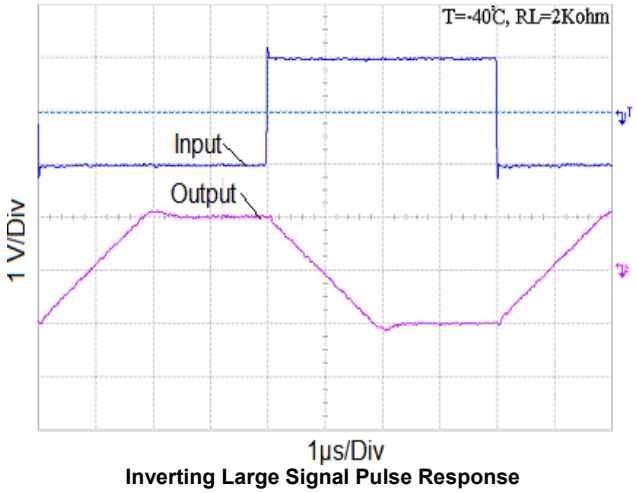
Typical Performance Characteristics (cont.)



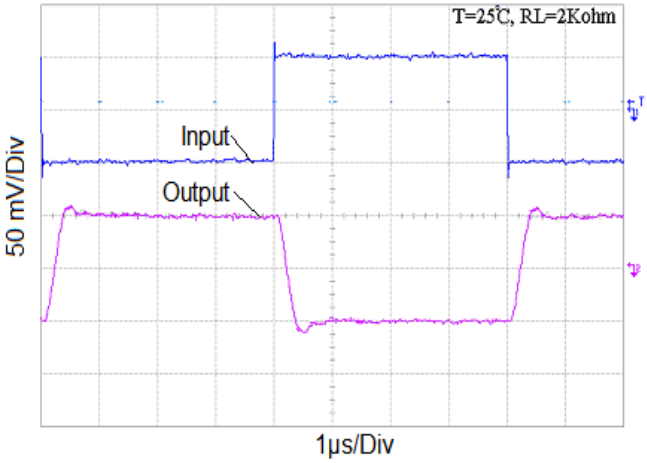
Inverting Large Signal Pulse Response



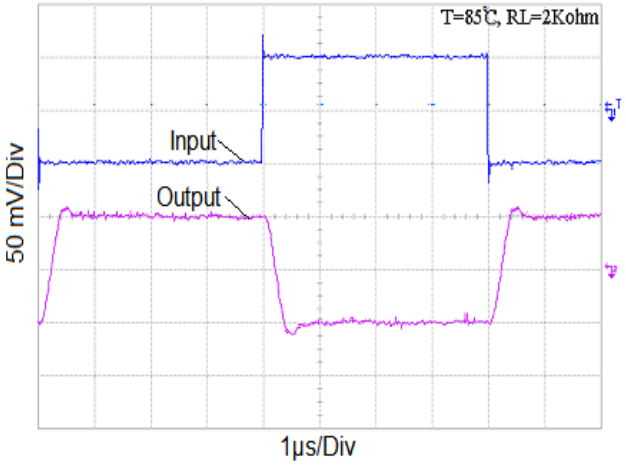
Inverting Large Signal Pulse Response



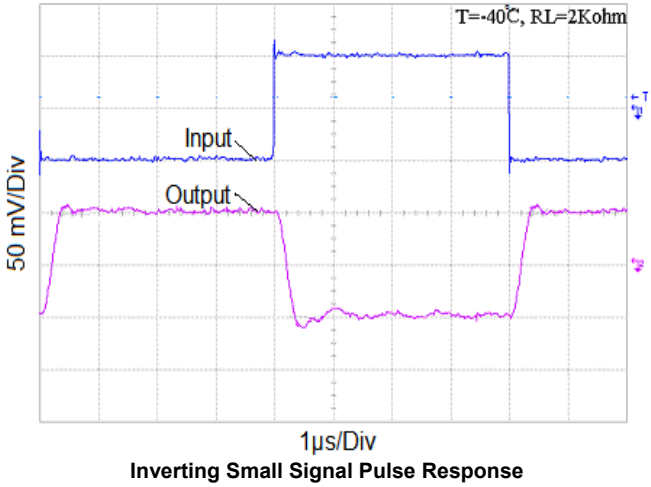
Inverting Large Signal Pulse Response



Inverting Small Signal Pulse Response

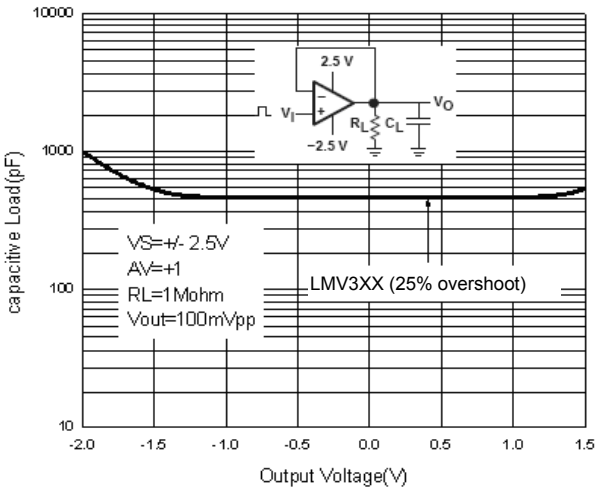


Inverting Small Signal Pulse Response

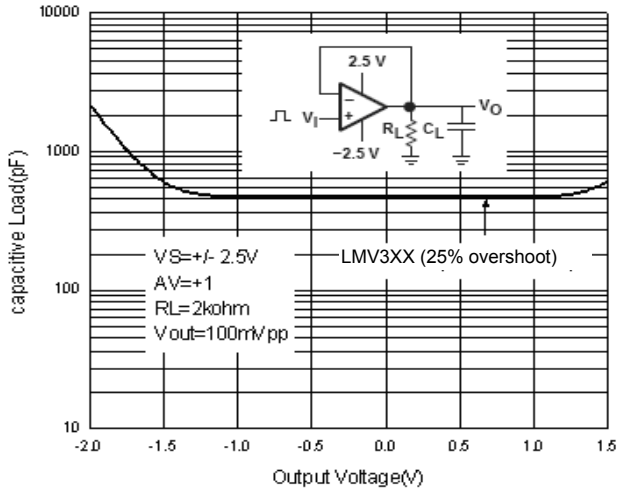


Inverting Small Signal Pulse Response

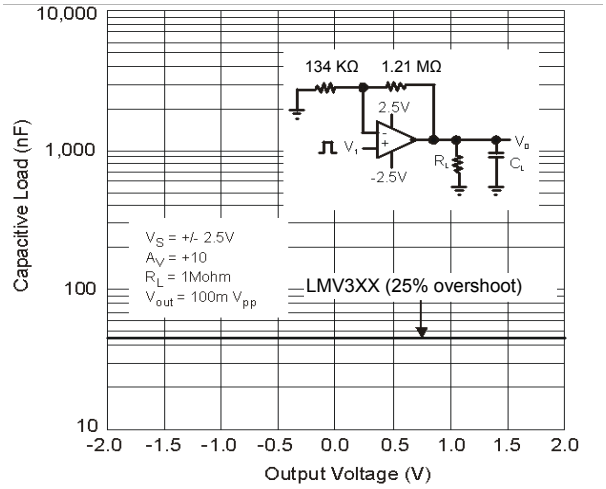
Typical Performance Characteristics (cont.)



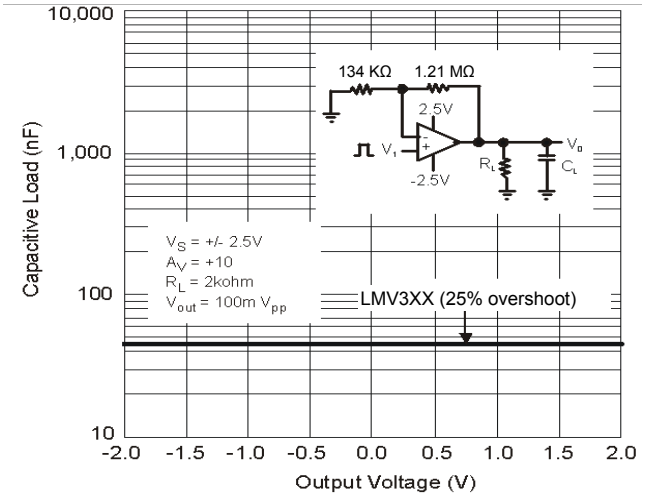
Stability vs. Capacitive Load



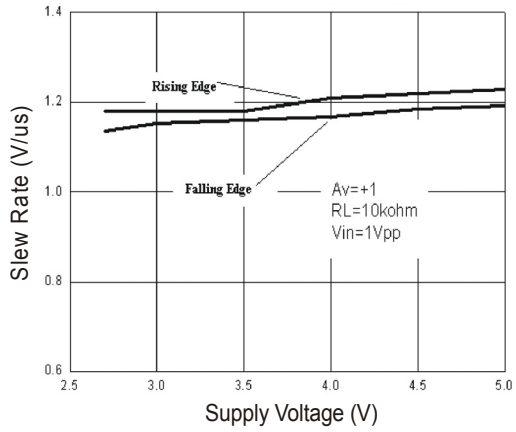
Stability vs. Capacitive Load



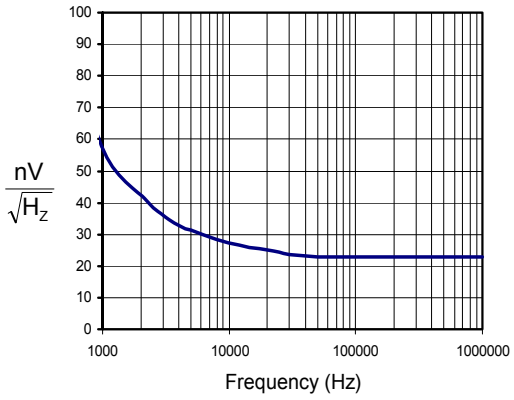
Stability vs. Capacitive Load



Stability vs. Capacitive Load



Slew Rate vs. Supply Voltage



Input Voltage Noise

Ordering Information

LMV3 XX XX G - X

Part Number	Package	Green	Packing
21 : Single (Note 12) 24 : Quad (Note 13) 58 : Dual (Note 14)	W : SOT25 SE : SOT353 B : SO-14 TS : TSSOP-14 S : SO-8 M8 : MSOP-8	G : Green	7/13 : Tape & Reel

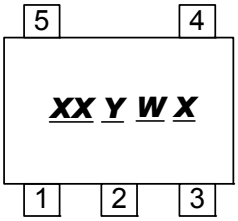
Part Number	Package Code	Packaging	7"/13" Tape and Reel	
			Quantity	Part Number Suffix
LMV321WG-7	W	SOT25	3000/Tape & Reel	-7
LMV321SEG-7	SE	SOT353	3000/Tape & Reel	-7
LMV324BG-13	B	SO-14	2500/Tape & Reel	-13
LMV324TSG-13	TS	TSSOP-14	2500/Tape & Reel	-13
LMV358SG-13	S	SO-8	2500/Tape & Reel	-13
LMV358M8G-13	M8	MSOP-8	2500/Tape & Reel	-13

Notes: 12. LMV321 is only available for SOT25 and SOT353.
13. LMV324 is only available for SO-14 and TSSOP-14.
14. LMV358 is only available for SO-8 and MSOP-8.

Marking Information

SOT25/SOT353

(Top View)



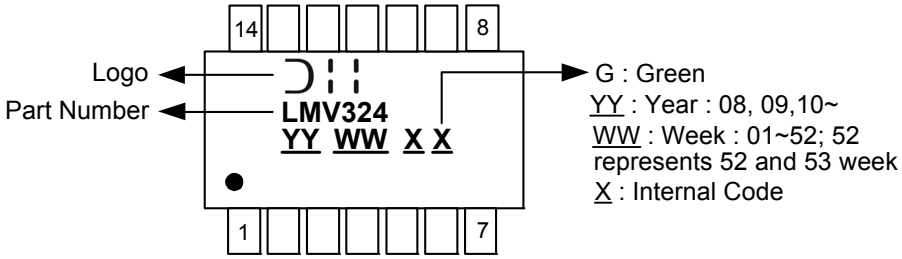
XX : Identification Code
Y : Year : 0~9
W : Week : A~Z : 1~26 week;
a~z : 27~52 week;
z represents 52 and 53 week
X : A~Z : Green

Device	Package type	Identification Code
LMV321W	SOT25	BX
LMV321SE	SOT353	BY

Marking Information (cont.)

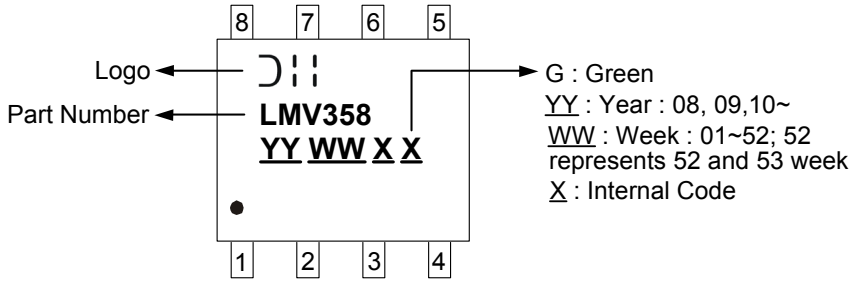
SO-14 / TSSOP-14

(Top View)



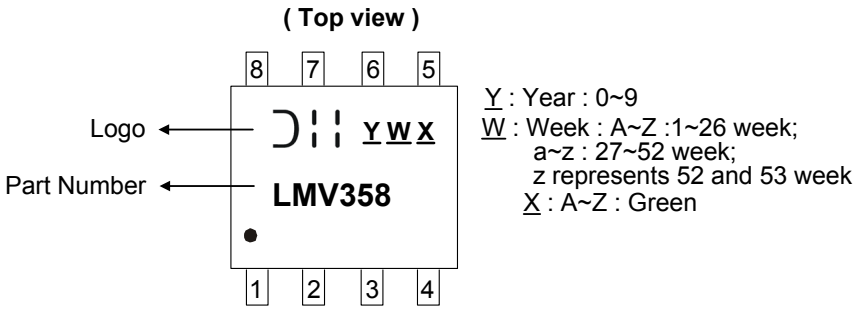
SO-8

(Top view)



MSOP-8

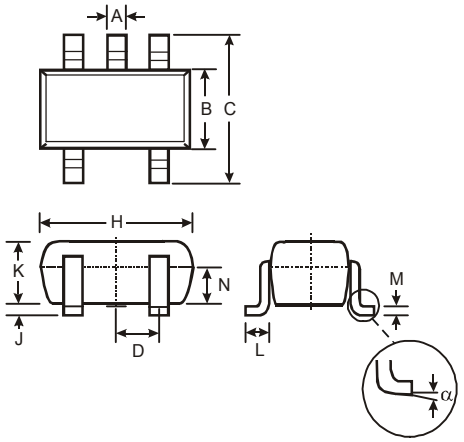
(Top view)



Package Outline Dimensions (All dimensions in mm.)

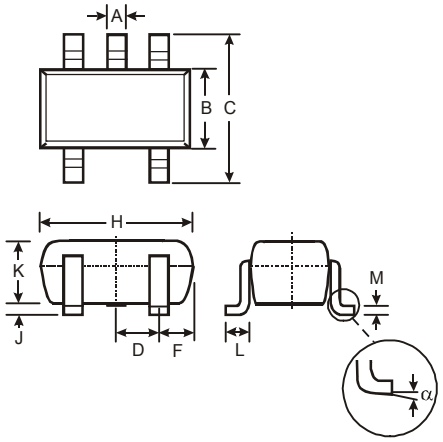
Please see AP02002 at http://www.diodes.com/datasheets/ap02002.pdf for latest version.

SOT25



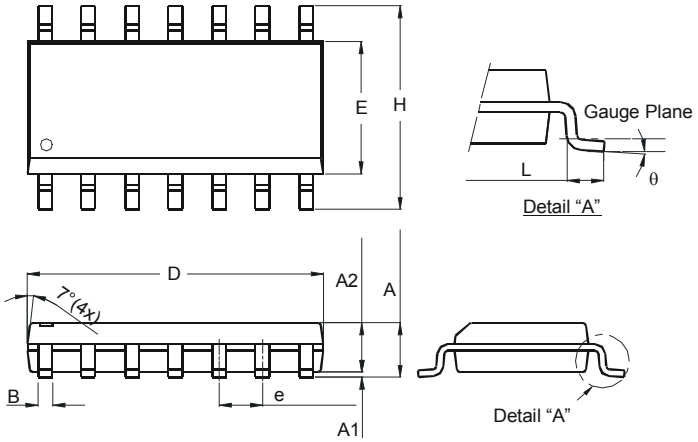
SOT25			
Dim	**Min**	**Max**	**Typ**
A	0.35	0.50	0.38
B	1.50	1.70	1.60
C	2.70	3.00	2.80
D	—	—	0.95
H	2.90	3.10	3.00
J	0.013	0.10	0.05
K	1.00	1.30	1.10
L	0.35	0.55	0.40
M	0.10	0.20	0.15
N	0.70	0.80	0.75
α	0°	8°	—
All Dimensions in mm			

SOT353



SOT353			
Dim	**Min**	**Max**	**Typ**
A	0.10	0.30	0.25
B	1.15	1.35	1.30
C	2.00	2.20	2.10
D	0.65 Typ		
F	0.40	0.45	0.425
H	1.80	2.20	2.15
J	0	0.10	0.05
K	0.90	1.00	1.00
L	0.25	0.40	0.30
M	0.10	0.22	0.11
α	0°	8°	-
All Dimensions in mm			

SO-14

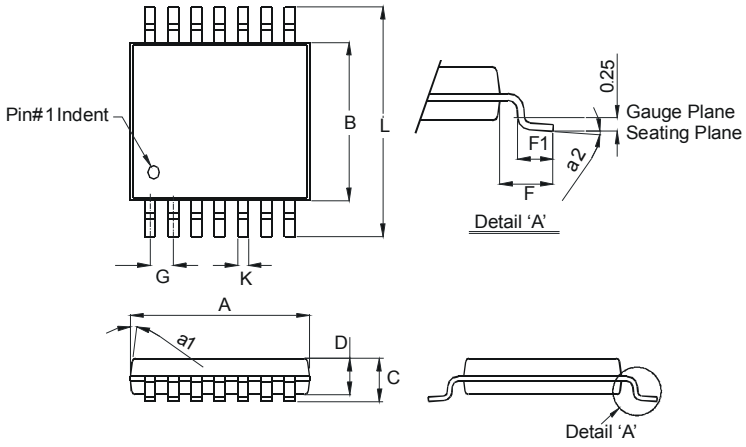


SO-14		
Dim	**Min**	**Max**
A	1.47	1.73
A1	0.10	0.25
A2	1.45 Typ	
B	0.33	0.51
D	8.53	8.74
E	3.80	3.99
e	1.27 Typ	
H	5.80	6.20
L	0.38	1.27
θ	0°	8°
All Dimensions in mm		

Package Outline Dimensions (cont.) (All dimensions in mm.)

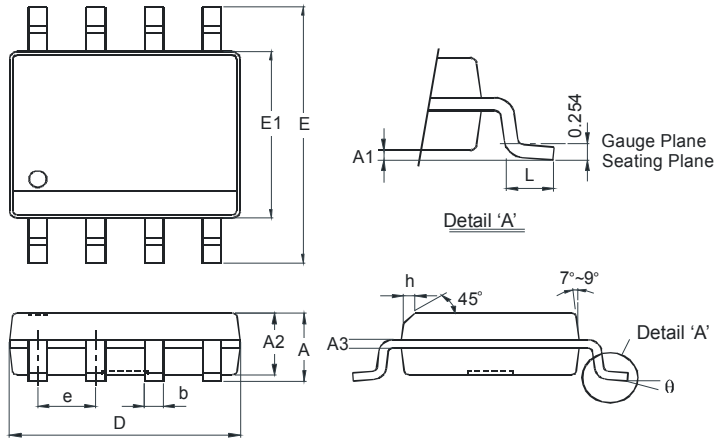
Please see AP02002 at http://www.diodes.com/datasheets/ap02002.pdf for latest version.

TSSOP-14



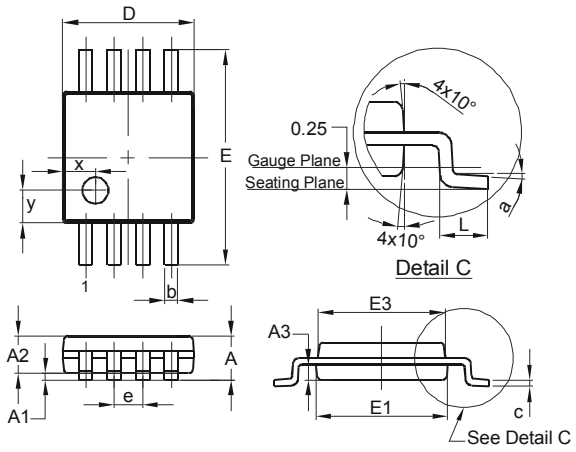
TSSOP-14		
Dim	**Min**	**Max**
a1	7° (4X)	
a2	0°	8°
A	4.9	5.10
B	4.30	4.50
C	—	1.2
D	0.8	1.05
F	1.00 Typ	
F1	0.45	0.75
G	0.65 Typ	
K	0.19	0.30
L	6.40 Typ	
All Dimensions in mm		

SO-8



SO-8		
Dim	**Min**	**Max**
A	-	1.75
A1	0.10	0.20
A2	1.30	1.50
A3	0.15	0.25
b	0.3	0.5
D	4.85	4.95
E	5.90	6.10
E1	3.85	3.95
e	1.27 Typ	
h	-	0.35
L	0.62	0.82
θ	0°	8°
All Dimensions in mm		

MSOP-8

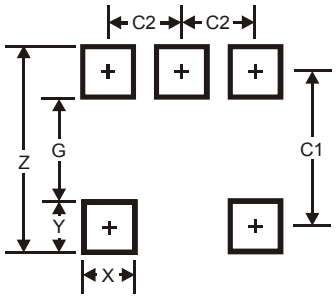


MSOP-8			
Dim	**Min**	**Max**	**Typ**
A	-	1.10	-
A1	0.05	0.15	0.10
A2	0.75	0.95	0.86
A3	0.29	0.49	0.39
b	0.22	0.38	0.30
c	0.08	0.23	0.15
D	2.90	3.10	3.00
E	4.70	5.10	4.90
E1	2.90	3.10	3.00
E3	2.85	3.05	2.95
e	-	-	0.65
L	0.40	0.80	0.60
a	0°	8°	4°
x	-	-	0.750
y	-	-	0.750
All Dimensions in mm			

Suggested Pad Layout

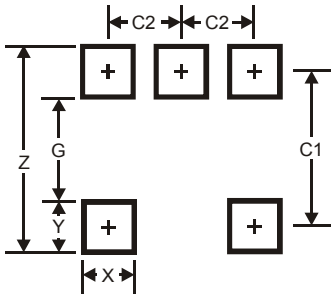
Please see AP02001 at http://www.diodes.com/datasheets/ap02001.pdf for the latest version.

SOT25



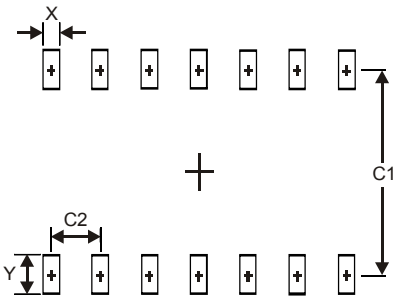
Dimensions	Value (in mm)
Z	3.20
G	1.60
X	0.55
Y	0.80
C1	2.40
C2	0.95

SOT353



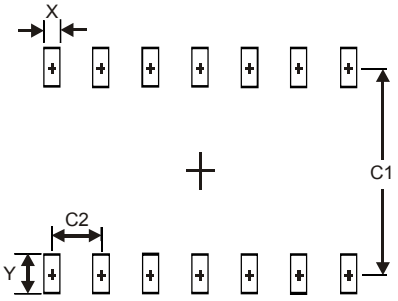
Dimensions	Value (in mm)
Z	2.5
G	1.3
X	0.42
Y	0.6
C1	1.9
C2	0.65

SO-14



Dimensions	Value (in mm)
X	0.60
Y	1.50
C1	5.4
C2	1.27

TSSOP-14

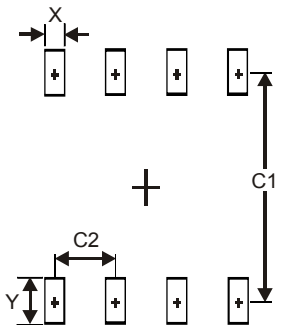


Dimensions	Value (in mm)
X	0.45
Y	1.45
C1	5.9
C2	0.65

Suggested Pad Layout (cont.)

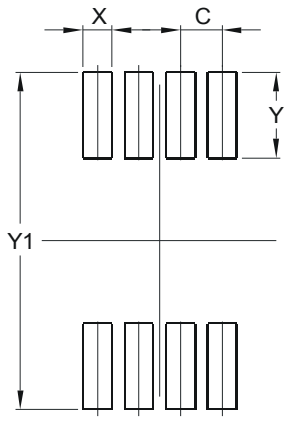
Please see AP02001 at http://www.diodes.com/datasheets/ap02001.pdf for the latest version.

SO-8



Dimensions	Value (in mm)
X	0.60
Y	1.55
C1	5.4
C2	1.27

MSOP-8



Dimensions	Value (in mm)
C	0.650
X	0.450
Y	1.350
Y1	5.300

IMPORTANT NOTICE

DIODES INCORPORATED MAKES NO WARRANTY OF ANY KIND, EXPRESS OR IMPLIED, WITH REGARDS TO THIS DOCUMENT, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE (AND THEIR EQUIVALENTS UNDER THE LAWS OF ANY JURISDICTION).

Diodes Incorporated and its subsidiaries reserve the right to make modifications, enhancements, improvements, corrections or other changes without further notice to this document and any product described herein. Diodes Incorporated does not assume any liability arising out of the application or use of this document or any product described herein; neither does Diodes Incorporated convey any license under its patent or trademark rights, nor the rights of others. Any Customer or user of this document or products described herein in such applications shall assume all risks of such use and will agree to hold Diodes Incorporated and all the companies whose products are represented on Diodes Incorporated website, harmless against all damages.

Diodes Incorporated does not warrant or accept any liability whatsoever in respect of any products purchased through unauthorized sales channel. Should Customers purchase or use Diodes Incorporated products for any unintended or unauthorized application, Customers shall indemnify and hold Diodes Incorporated and its representatives harmless against all claims, damages, expenses, and attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized application.

Products described herein may be covered by one or more United States, international or foreign patents pending. Product names and markings noted herein may also be covered by one or more United States, international or foreign trademarks.

This document is written in English but may be translated into multiple languages for reference. Only the English version of this document is the final and determinative format released by Diodes Incorporated.

LIFE SUPPORT

Diodes Incorporated products are specifically not authorized for use as critical components in life support devices or systems without the express written approval of the Chief Executive Officer of Diodes Incorporated. As used herein:

A. Life support devices or systems are devices or systems which:

1. are intended to implant into the body, or
2. support or sustain life and whose failure to perform when properly used in accordance with instructions for use provided in the labeling can be reasonably expected to result in significant injury to the user.

B. A critical component is any component in a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or to affect its safety or effectiveness.

Customers represent that they have all necessary expertise in the safety and regulatory ramifications of their life support devices or systems, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of Diodes Incorporated products in such safety-critical, life support devices or systems, notwithstanding any devices- or systems-related information or support that may be provided by Diodes Incorporated. Further, Customers must fully indemnify Diodes Incorporated and its representatives against any damages arising out of the use of Diodes Incorporated products in such safety-critical, life support devices or systems.

www.diodes.com