

### Features

- Operating range from  $V_{CC} = 2.7\text{ V}$  to  $6\text{ V}$
- Rail-to-rail input and output
- Extended  $V_{icm}$  ( $V_{DD} - 0.2\text{ V}$  to  $V_{CC} + 0.2\text{ V}$ )
- Low supply current ( $145\text{ }\mu\text{A}$ )
- Gain bandwidth product ( $1\text{ MHz}$ )
- ESD tolerance ( $2\text{ kV}$ )
- Latch-up immunity
- Available in SOT23-5 micropackage

### Applications

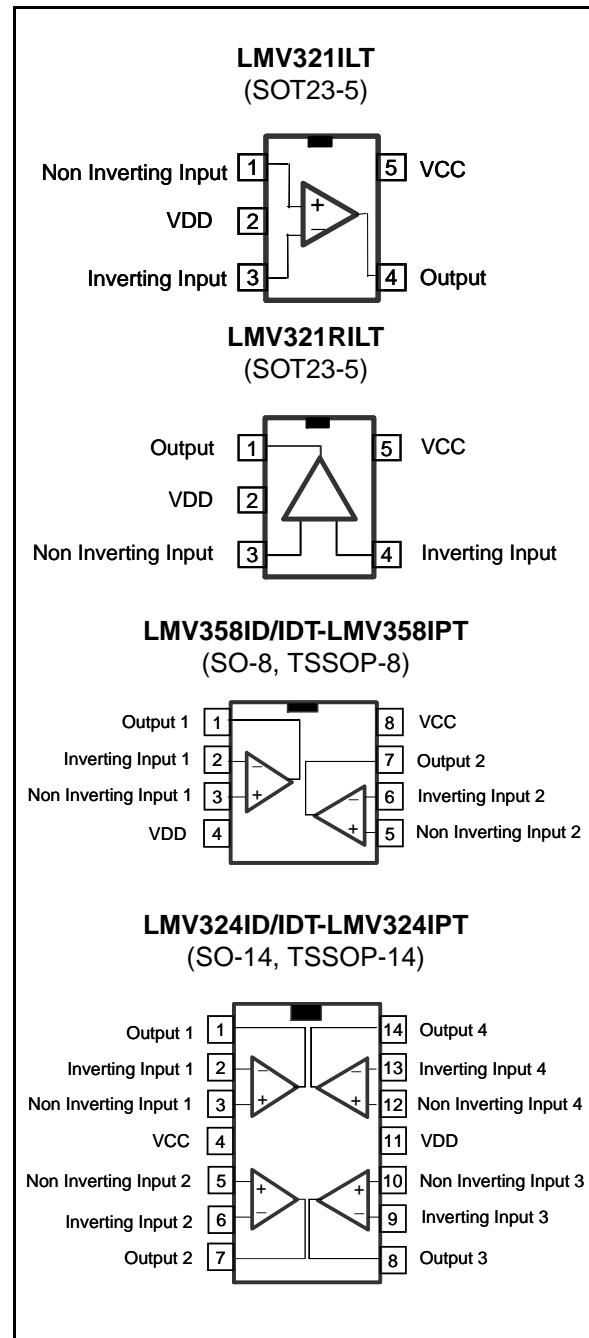
- Two-cell battery-powered systems
- Battery-powered electronic equipment
- Cordless phones
- Personal medical care (glucose meter)
- Laptops
- PDAs

### Description

The LMV321/358/324 family (single, dual and quad) answers the need for low cost, general purpose operational amplifiers. They operate with voltages as low as  $2.7\text{ V}$  and feature both input and output rail-to-rail,  $145\text{ }\mu\text{A}$  consumption current and  $1\text{ MHz}$  gain bandwidth product (GBP).

With a such low consumption and a sufficient GBP for many applications, these op-amps are very well-suited for any kind of battery-supplied and portable equipment application.

The LMV321 is housed in the space-saving 5-pin SOT23-5 package which simplifies the board design (overall dimensions are  $2.8\text{ mm} \times 2.9\text{ mm}$ ). The SOT23-5 has two pinning configurations to answer all application requirements.



# 1 Absolute maximum ratings and operating conditions

**Table 1. Absolute maximum ratings**

Symbol	Parameter	Value	Unit
$V_{CC}$	Supply voltage <sup>(1)</sup>	7	V
$V_{id}$	Differential input voltage <sup>(2)</sup>	$\pm 1$	V
$V_{in}$	Input voltage	$V_{DD}-0.3$ to $V_{CC}+0.3$	V
$T_{oper}$	Operating free air temperature range	-40 to + 125	°C
$T_{stg}$	Storage temperature	-65 to +150	°C
$T_j$	Maximum junction temperature	150	°C
$R_{thja}$	Thermal resistance junction to ambient <sup>(3)</sup> SOT23-5 SO-8 SO-14 TSSOP8 TSSOP14	250 125 103 120 100	°C/W
$R_{thjc}$	Thermal resistance junction to case <sup>(3)</sup> SOT23-5 SO-8 SO-14 TSSOP8 TSSOP14	81 40 31 37 32	°C/W
ESD	HBM: human body model <sup>(4)</sup>	2	kV
	MM: machine model <sup>(5)</sup>	200	V
	CDM: charged device model <sup>(6)</sup>	1.5	kV
	Lead temperature (soldering, 10sec)	250	°C
	Output short-circuit duration	see note <sup>(7)</sup>	

1. All voltage values, except differential voltage are with respect to network terminal.
2. Differential voltages are the non-inverting input terminal with respect to the inverting input terminal. If  $V_{id} > \pm 1$  V, the maximum input current must not exceed  $\pm 1$  mA. In this case ( $V_{id} > \pm 1$  V), an input series resistor must be added to limit input current.
3. Short-circuits can cause excessive heating. Destructive dissipation can result from simultaneous short-circuits on all amplifiers. All values are typical.
4. Human body model: A 100 pF capacitor is charged to the specified voltage, then discharged through a 1.5 kΩ resistor between two pins of the device. This is done for all couples of connected pin combinations while the other pins are floating.
5. Machine model: A 200 pF capacitor is charged to the specified voltage, then discharged directly between two pins of the device with no external series resistor (internal resistor  $< 5$  Ω). This is done for all couples of connected pin combinations while the other pins are floating.
6. Charged device model: all pins and the package are charged together to the specified voltage and then discharged directly to the ground through only one pin. This is done for all pins.  
No value specified for CDM on SOT23-5L package. The value is given for SO and TSSOP packages.
7. Short-circuits from the output to  $V_{CC}$  can cause excessive heating. The maximum output current is approximately 48 mA, independent of the magnitude of  $V_{CC}$ . Destructive dissipation can result from simultaneous short-circuits on all amplifiers.

**Table 2. Operating conditions**

Symbol	Parameter	Value	Unit
$V_{CC}$	Supply voltage	2.7 to 6	V
$V_{icm}$	Common mode input voltage range <sup>(1)</sup>	$V_{DD} -0.2$ to $V_{CC} + 0.2$	V
$V_{icm}$	Common mode input voltage range <sup>(2)</sup>	$V_{DD}$ to $V_{CC}$	V
$T_{oper}$	Operating free air temperature range	-40 to + 125	°C

1. At 25°C, for  $2.7 \leq V_{CC} \leq 6$  V,  $V_{icm}$  is extended to  $V_{DD} - 0.2$  V,  $V_{CC} + 0.2$  V.

2. In full temperature range, both rails can be reached when  $V_{CC}$  does not exceed 5.5 V.

## 2 Electrical characteristics

**Table 3.**  $V_{CC} = +2.7V$ ,  $V_{DD} = 0V$ ,  $C_L$  &  $R_L$  connected to  $V_{CC}/2$ ,  $T_{amb} = 25^\circ C$  (unless otherwise specified)

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
$V_{io}$	Input offset voltage	$V_{icm} = V_{out} = V_{CC}/2$ $T_{min} \leq T_{amb} \leq T_{max}$		0.1 6	3	mV
$\Delta V_{io}$	Input offset voltage drift			2		$\mu V/^\circ C$
$I_{io}$	Input offset current	$V_{icm} = V_{out} = V_{CC}/2$ (1) $T_{min} \leq T_{amb} \leq T_{max}$		1 25	9	nA
$I_{ib}$	Input bias current	$V_{icm} = V_{out} = V_{CC}/2$ (1) $T_{min} \leq T_{amb} \leq T_{max}$		10 85	50	nA
CMR	Common mode rejection ratio	$0 \leq V_{icm} \leq V_{CC}$	55	85		dB
SVR	Supply voltage rejection ratio	$V_{icm} = V_{CC}/2$	70	80		dB
$A_{vd}$	Large signal voltage gain	$V_{out} = 0.5V$ to $2.2V$ $R_L = 10k\Omega$ $R_L = 2k\Omega$	80 70	100 88		dB
$V_{OH}$	High level output voltage	$V_{id} = 100mV$ $T_{min} \leq T_{amb} \leq T_{max}$ $R_L = 10k\Omega$ $R_L = 2k\Omega$	2.6 2.55	2.65 2.6		V
$V_{OL}$	Low level output voltage	$V_{id} = -100mV$ $T_{min} \leq T_{amb} \leq T_{max}$ $R_L = 10k\Omega$ $R_L = 2k\Omega$		15 50	90 100	mV
$I_o$	Output current	Output source current $V_{id} = 100mV$ , $V_O = V_{DD}$ Output sink current $V_{id} = -100mV$ , $V_O = V_{CC}$	5 5	46 46		mA
$I_{CC}$	Supply current (per amplifier)	$V_{out} = V_{CC}/2$ $A_{VCL} = 1$ , no load $T_{min} \leq T_{amb} \leq T_{max}$		145 230	200	$\mu A$
GBP	Gain bandwidth product	$R_L = 10k\Omega$ , $C_L = 100pF$ , $f = 100kHz$		1		MHz
SR	Slew rate	$R_L = 600\Omega$ , $C_L = 100pF$ , $A_V = 1$		0.35		V/ $\mu s$
$\phi_m$	Phase margin	$R_L = 600\Omega$ , $C_L = 100pF$		44		Degrees
en	Input voltage noise			40		nV/ $\sqrt{Hz}$
THD	Total harmonic distortion			0.01		%

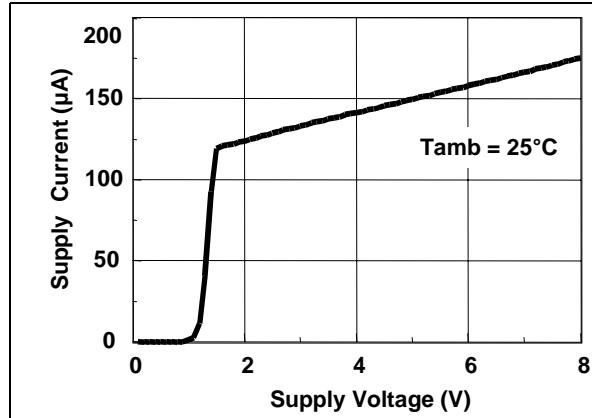
1. Maximum values include unavoidable inaccuracies of the industrial tests.

**Table 4.**  $V_{CC} = +5V$ ,  $V_{DD} = 0V$ ,  $C_L$  &  $R_L$  connected to  $V_{CC}/2$ ,  $T_{amb} = 25^\circ C$  (unless otherwise specified)

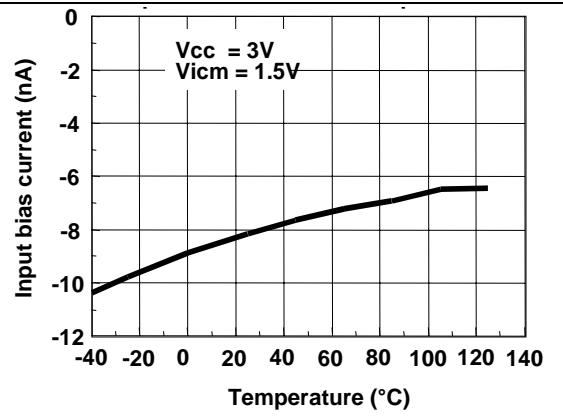
Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
$V_{io}$	Input offset voltage	$V_{icm} = V_{out} = V_{CC}/2$ $T_{min} \leq T_{amb} \leq T_{max}$		0.1 6	3 6	mV
$\Delta V_{io}$	Input offset voltage drift			2		$\mu V/^\circ C$
$I_{io}$	Input offset current	$V_{icm} = V_{out} = V_{CC}/2$ <sup>(1)</sup> $T_{min} \leq T_{amb} \leq T_{max}$		1 25	9 25	nA
$I_{ib}$	Input bias current	$V_{icm} = V_{out} = V_{CC}/2$ <sup>(1)</sup> $T_{min} \leq T_{amb} \leq T_{max}$		16 95	63 95	nA
CMR	Common mode rejection ratio	$0 \leq V_{icm} \leq V_{CC}$	65	95		dB
SVR	Supply voltage rejection ratio	$V_{icm} = V_{CC}/2$	70	90		dB
$A_{vd}$	Large signal voltage gain	$V_{out} = 0.5V$ to $4.5V$ $R_L = 10k\Omega$ $R_L = 2k\Omega$	85 77	97 93		dB
$V_{OH}$	High level output voltage	$V_{id} = 100mV$ $T_{min} \leq T_{amb} \leq T_{max}$ $R_L = 10k\Omega$ $R_L = 2k\Omega$	4.85 4.8	4.95 4.91		V
$V_{OL}$	Low level output voltage	$V_{id} = -100mV$ $T_{min} \leq T_{amb} \leq T_{max}$ $R_L = 10k\Omega$ $R_L = 2k\Omega$		40 80	180 200	mV
$I_o$	Output current	Output source current $V_{id} = 100mV$ , $V_O = V_{DD}$ Output sink current $V_{id} = -100mV$ , $V_O = V_{CC}$	7 7	48 48		mA
$I_{CC}$	Supply current (per amplifier)	$V_{out} = V_{CC}/2$ $A_{VCL} = 1$ , no load $T_{min} \leq T_{amb} \leq T_{max}$		162 250	220 250	$\mu A$
GBP	Gain bandwidth product	$R_L = 10k\Omega$ , $C_L = 100pF$ , $f = 100kHz$		1.3		MHz
SR	Slew rate	$R_L = 600\Omega$ , $C_L = 100pF$ , $A_V = 1$		0.45		V/ $\mu$ s
$\phi_m$	Phase margin	$R_L = 600\Omega$ , $C_L = 100pF$		48		Degrees
en	Input voltage noise			40		nV/ $\sqrt{Hz}$
THD	Total harmonic distortion			0.01		%

1. Maximum values include unavoidable inaccuracies of the industrial tests.

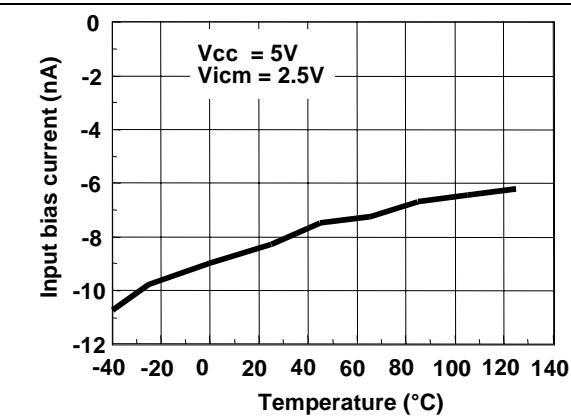
**Figure 1.** Supply current/amplifier vs. supply voltage



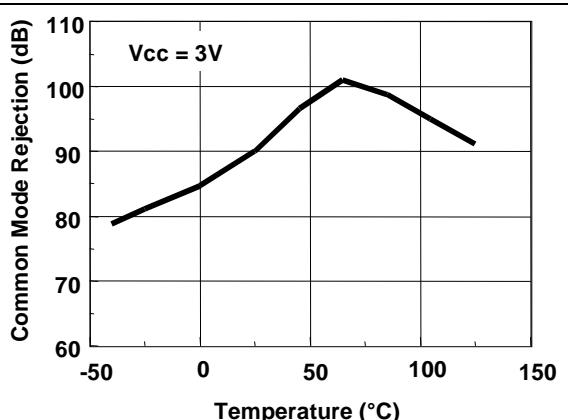
**Figure 2.** Input bias current vs. temperature



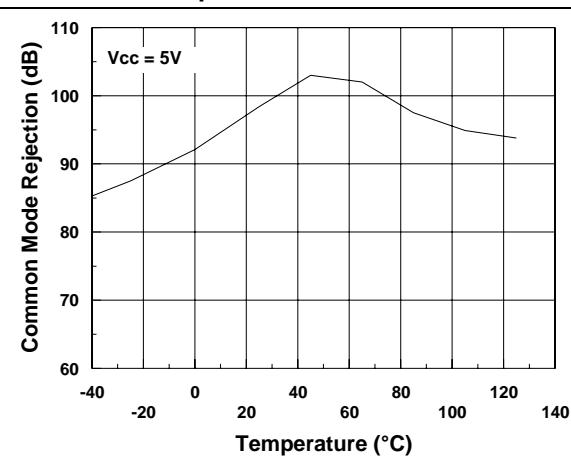
**Figure 3.** Input bias current vs. temperature



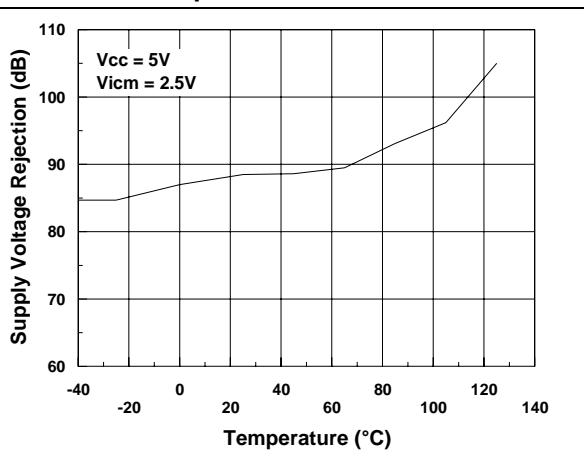
**Figure 4.** Common mode rejection vs. temperature

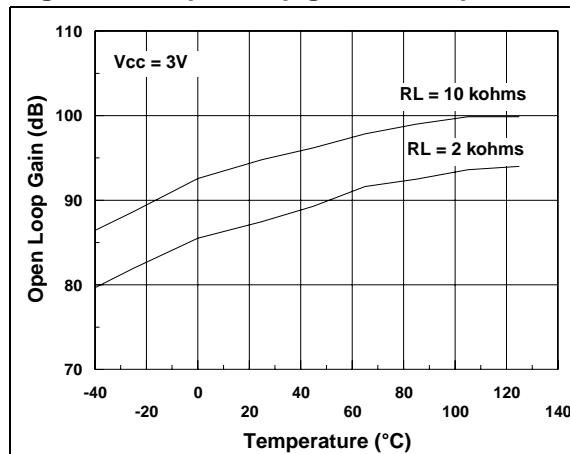
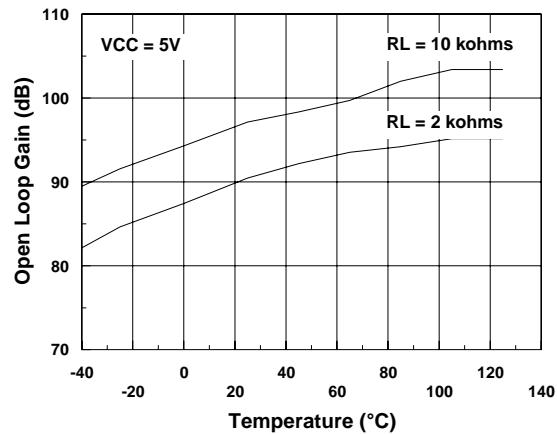
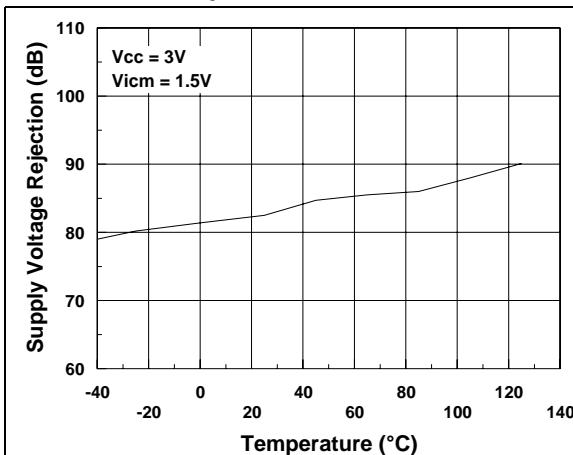
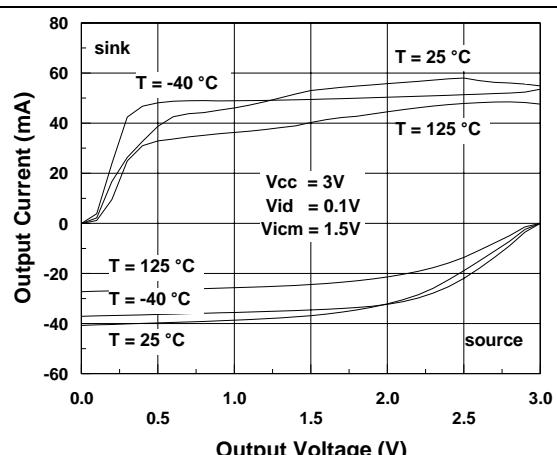
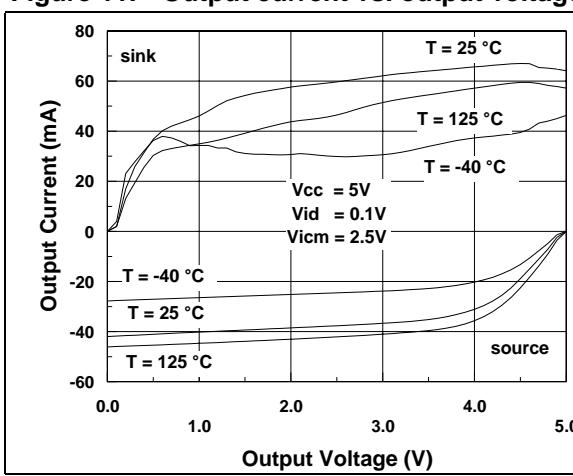
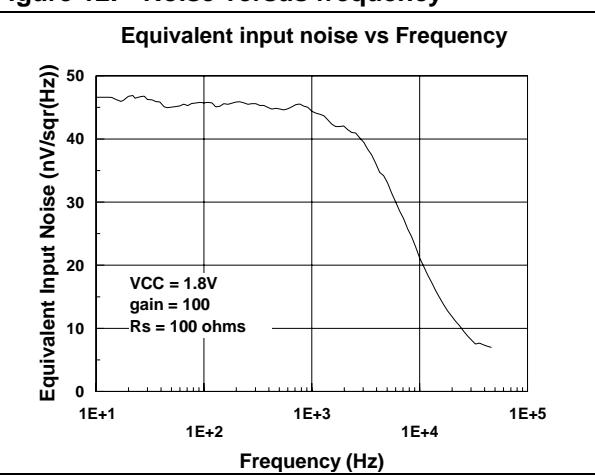


**Figure 5.** Common mode rejection vs. temperature



**Figure 6.** Supply voltage rejection vs. temperature



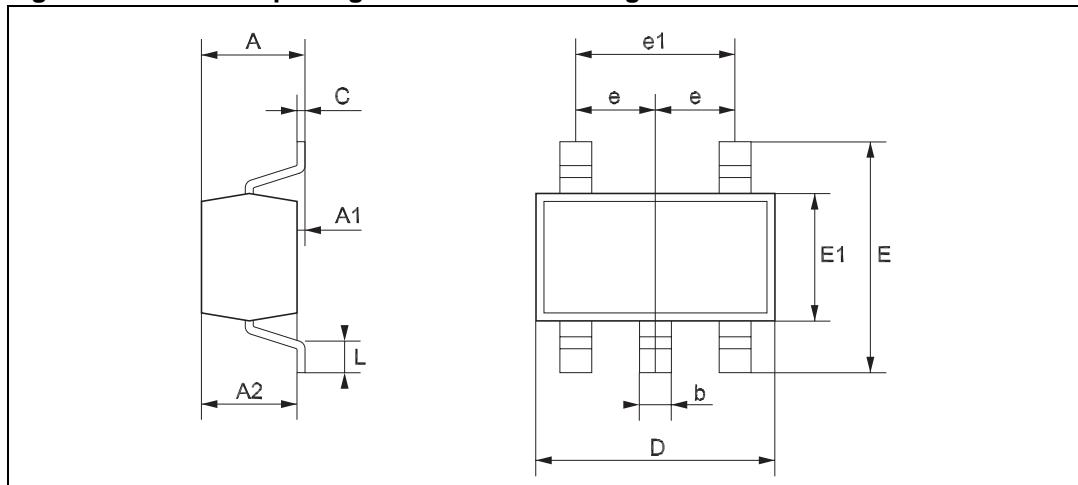
**Figure 7.** Open loop gain vs. temperature**Figure 8.** Open loop gain vs. temperature**Figure 9.** Supply voltage rejection vs. temperature**Figure 10.** Output current vs. output voltage**Figure 11.** Output current vs. output voltage**Figure 12.** Noise versus frequency

### 3 Package information

In order to meet environmental requirements, STMicroelectronics offers these devices in ECOPACK® packages. These packages have a lead-free second level interconnect. The category of second level interconnect is marked on the package and on the inner box label, in compliance with JEDEC Standard JESD97. The maximum ratings related to soldering conditions are also marked on the inner box label. ECOPACK is an STMicroelectronics trademark. ECOPACK specifications are available at: [www.st.com](http://www.st.com).

#### 3.1 SOT23-5 package information

**Figure 13.** SOT23-5 package mechanical drawing

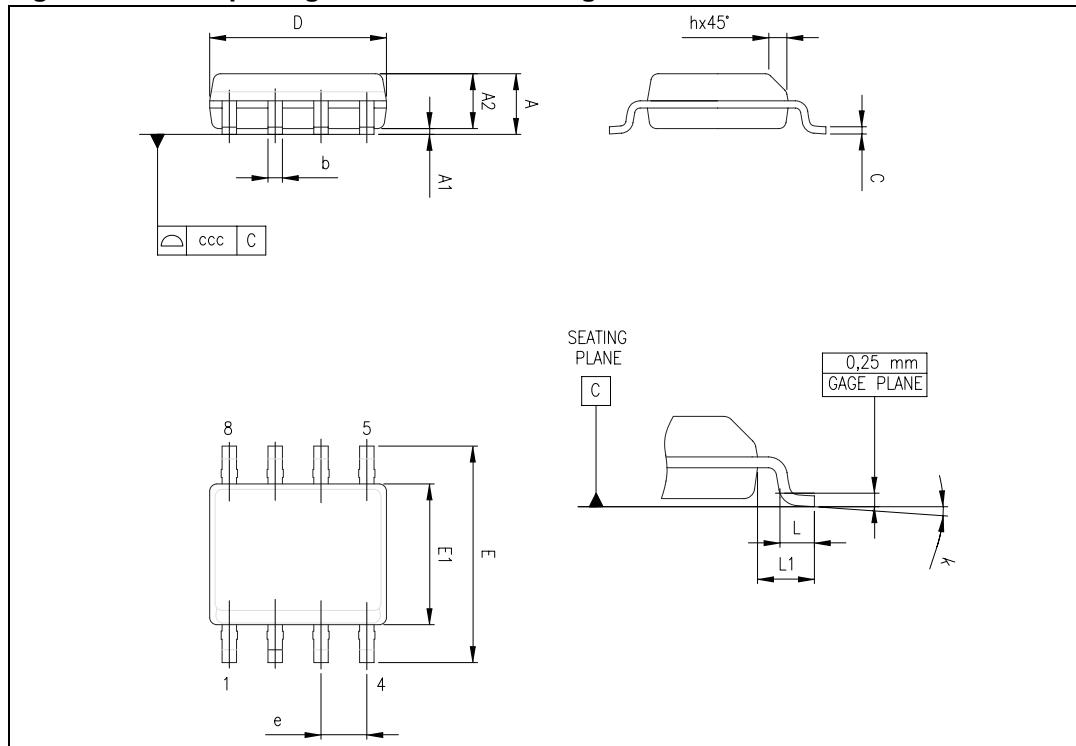


**Table 5.** SOT23-5 package mechanical data

Ref.	Dimensions					
	Millimeters			Mils		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A	0.90		1.45	35.4		57.1
A1	0.00		0.15	0.00		5.9
A2	0.90		1.30	35.4		51.2
b	0.35		0.50	13.7		19.7
C	0.09		0.20	3.5		7.8
D	2.80		3.00	110.2		118.1
E	2.60		3.00	102.3		118.1
E1	1.50		1.75	59.0		68.8
e		0.95			37.4	
e1		1.9			74.8	
L	0.35		0.55	13.7		21.6

### 3.2 SO-8 package information

**Figure 14.** SO-8 package mechanical drawing



**Table 6.** SO-8 package mechanical data

Ref.	Dimensions					
	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.75			0.069
A1	0.10		0.25	0.004		0.010
A2	1.25			0.049		
b	0.28		0.48	0.011		0.019
c	0.17		0.23	0.007		0.010
D	4.80	4.90	5.00	0.189	0.193	0.197
E	5.80	6.00	6.20	0.228	0.236	0.244
E1	3.80	3.90	4.00	0.150	0.154	0.157
e		1.27			0.050	
h	0.25		0.50	0.010		0.020
L	0.40		1.27	0.016		0.050
k	1°		8°	1°		8°
ccc			0.10			0.004

### 3.3 TSSOP8 package information

Figure 15. TSSOP8 package mechanical drawing

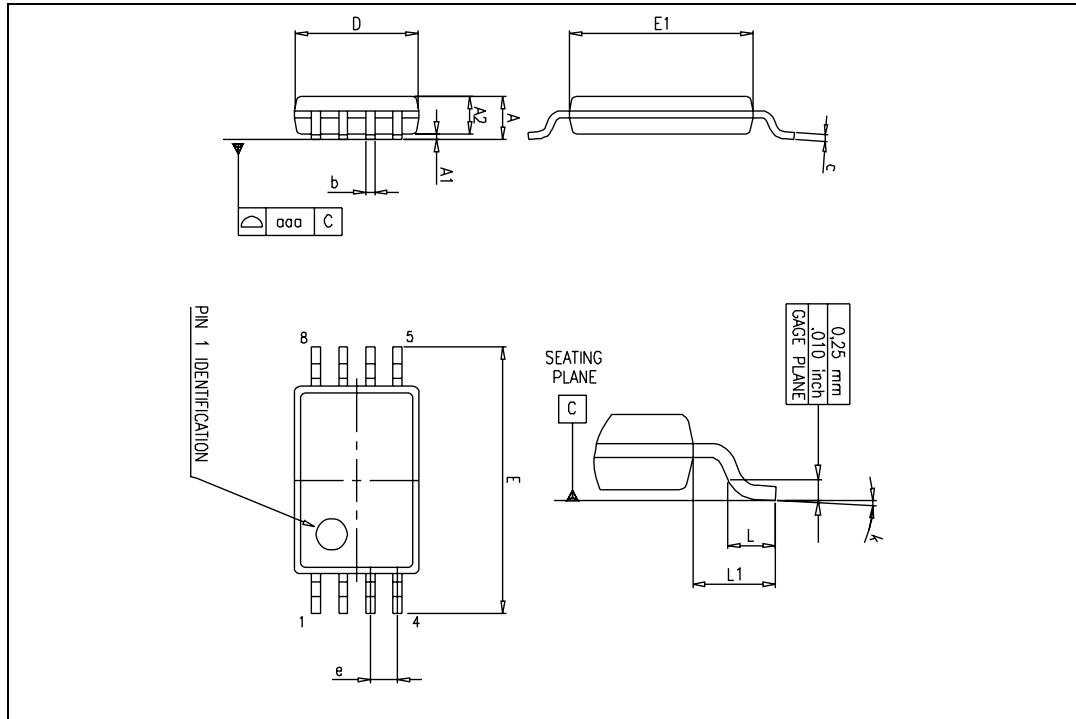


Table 7. TSSOP8 package mechanical data

Ref.	Dimensions					
	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.2			0.047
A1	0.05		0.15	0.002		0.006
A2	0.80	1.00	1.05	0.031	0.039	0.041
b	0.19		0.30	0.007		0.012
c	0.09		0.20	0.004		0.008
D	2.90	3.00	3.10	0.114	0.118	0.122
E	6.20	6.40	6.60	0.244	0.252	0.260
E1	4.30	4.40	4.50	0.169	0.173	0.177
e		0.65			0.0256	
k	0°		8°	0°		8°
L	0.45	0.60	0.75	0.018	0.024	0.030
L1		1			0.039	
aaa		0.1			0.004	

### 3.4 SO-14 package information

Figure 16. SO-14 package mechanical drawing

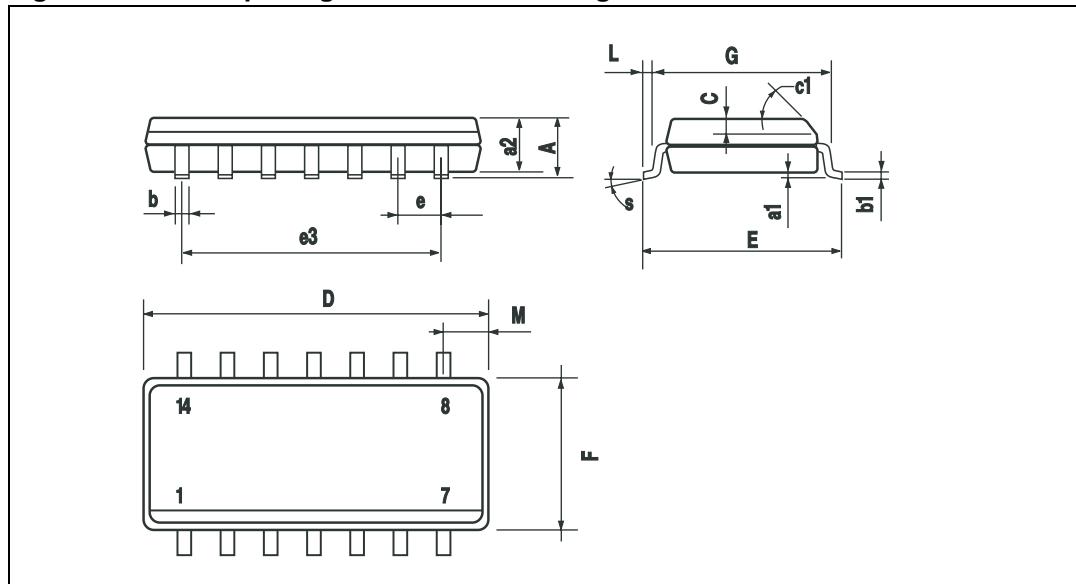
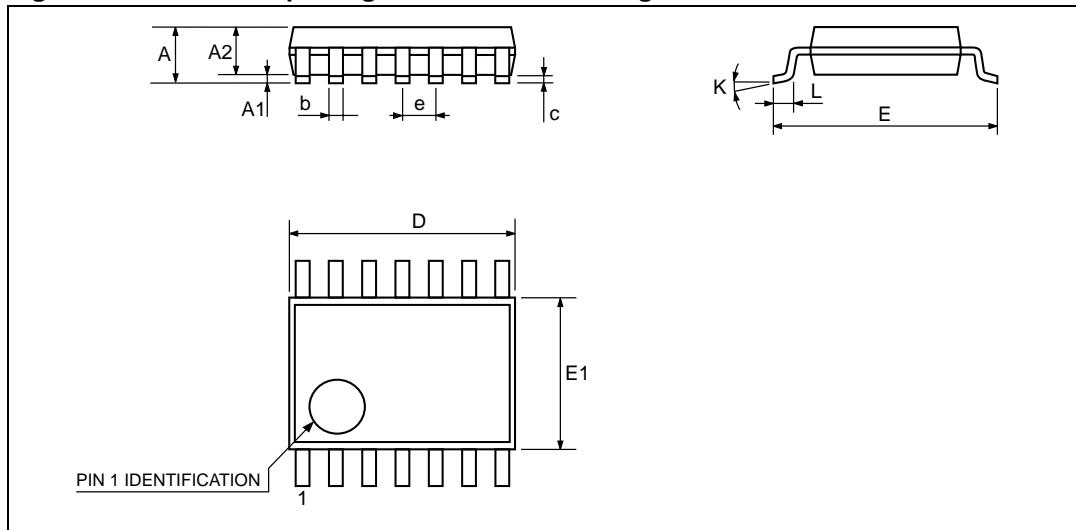


Table 8. SO-14 package mechanical data

Ref.	Dimensions					
	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.75			0.068
$a_1$	0.1		0.2	0.003		0.007
$a_2$			1.65			0.064
b	0.35		0.46	0.013		0.018
$b_1$	0.19		0.25	0.007		0.010
C		0.5			0.019	
$c_1$	$45^\circ$ (typ.)					
D	8.55		8.75	0.336		0.344
E	5.8		6.2	0.228		0.244
$e$		1.27			0.050	
$e_3$		7.62			0.300	
F	3.8		4.0	0.149		0.157
G	4.6		5.3	0.181		0.208
L	0.5		1.27	0.019		0.050
M			0.68			0.026
S	$8^\circ$ (max.)					

### 3.5 TSSOP14 package information

**Figure 17.** TSSOP14 package mechanical drawing



**Figure 18.** TSSOP14 package mechanical data

Ref.	Dimensions					
	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.2			0.047
A1	0.05		0.15	0.002	0.004	0.006
A2	0.8	1	1.05	0.031	0.039	0.041
b	0.19		0.30	0.007		0.012
c	0.09		0.20	0.004		0.0089
D	4.9	5	5.1	0.193	0.197	0.201
E	6.2	6.4	6.6	0.244	0.252	0.260
E1	4.3	4.4	4.48	0.169	0.173	0.176
e		0.65 BSC			0.0256 BSC	
K	0°		8°	0°		8°
L1	0.45	0.60	0.75	0.018	0.024	0.030

## 4 Ordering information

**Table 9. Order codes**

Order code	Temperature range	Package	Packaging	Marking
LMV321ILT	-40°C, +125 °C	SOT23-5	Tape & reel	K177
LMV321RILT				K176
LMV321IYLT <sup>(1)</sup>		SOT23-5 (Automotive grade)	Tape & reel	K180
LMV321RIYLT <sup>(1)</sup>				K185
LMV358ID		SO-8	Tube or tape & reel	LMV358
LMV358IDT				
LMV358IYD <sup>(1)</sup>		SO-8 (Automotive grade)	Tube or tape & reel	LMV358IY
LMV358IYDT <sup>(1)</sup>				
LMV358IPT		TSSOP8	Tape & reel	MV358
LMV358IYPT <sup>(1)</sup>				K181Y
LMV324ID	-40°C, +125 °C	SO-14	Tube or tape & reel	LMV324
LMV324IDT				
LMV324IYD <sup>(1)</sup>		SO-14 (Automotive grade)	Tube or tape & reel	V324Y
LMV324IYDT <sup>(1)</sup>				
LMV324IPT		TSSOP14	Tape & reel	MV324
LMV324IYPT <sup>(1)</sup>				V324IY

1. Qualification and characterization according to AEC Q100 and Q003 or equivalent, advanced screening according to AEC Q001 & Q 002 or equivalent are on-going.

## 5 Revision history

**Table 10. Document revision history**

Date	Revision	Changes
1-Dec-2005	1	First release - Products in full production.
25-May-2007	2	Added automotive grade part numbers to order codes table. Moved order codes table to <a href="#">Section 4 on page 13</a> .
20-Feb-2008	3	Added <a href="#">Figure 12: Noise versus frequency on page 7</a> . Updated presentation of package information. Corrected footnote for automotive grade part numbers in order codes table.

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