TSV991-TSV992-TSV994

Rail-to-rail input/output 20MHz GBP operational amplifiers

Features

- Low input offset voltage: 1.5mV max
- Rail-to-rail input and output
- Wide bandwidth 20MHz, stable for gain ≥3
- Low power consumption: 1.1mA maximum
- High output current: 35mA
- Operating from 2.5V to 5.5V
- Low input bias current, 1pA typ
- ESD internal protection ≥ 5kV
- Latch-up immunity

Description

The TSV991/2/4 family of single, dual & quad operational amplifiers offers low voltage operation and rail-to-rail input and output.

This family features an excellent speed/power consumption ratio, offering a 20MHz gain-bandwidth, stable for gain above 3 (100pF capacitive load), while consuming only 1.1mA max at 5V supply voltage. It also features an ultra-low input bias current.

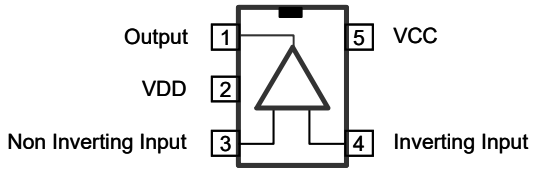
These characteristics make the TSV991/2/4 family ideal for sensor interfaces, battery-supplied and portable applications, as well as active filtering.

Applications

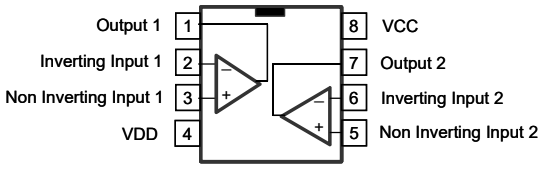
- Battery-powered applications
- Portable devices
- Signal conditioning
- Active filtering
- Medical instrumentation

Pin connections (top view)

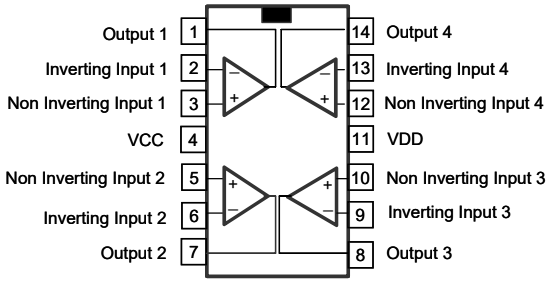
SOT23-5



MSO-8, SO-8



SO-14, TSSOP14



Contents

1 Absolute maximum ratings & operating conditions

Table 1. Absolute maximum ratings (AMR)

Symbol	Parameter	Value	Unit
V_{CC}	Supply voltage(1)	6	V
V_{id}	Differential input voltage (2)	$\pm V_{CC}$	V
V_{in}	Input voltage (3)	V_{DD}-0.2 to V_{CC}+0.2	V
T_{stg}	Storage temperature	-65 to +150	°C
R_{thja}	Thermal resistance junction to ambient(4) (5)		°C/W
	SOT23-5	250	
	SO-8	125	
	MiniSO-8	190	
	SO-14	103	
	TSSOP14	100	
R_{thjc}	Thermal resistance junction to case		°C/W
	SOT23-5	81	
	SO-8	40	
	MiniSO8	39	
	SO14	31	
	TSSOP14	32	
T_j	Maximum junction temperature	150	°C
ESD	HBM: human body model(6)	5	kV
	MM: machine model(7)	400	V
	CDM: charged device model(8) SOT23-5, SO-8, MSO8, SO14 TSSOP14	 1500 750	V
	Latch-up immunity	200	mA

1. Value with respect to V_{DD} pin.
2. Differential voltages are the non-inverting input terminal with respect to the inverting input terminal.
3. V_{CC}-V_{in} must not exceed 6V.
4. Short-circuits can cause excessive heating and destructive dissipation.
5. R_{th} are typical values.
6. Human body model: 100pF discharged through a 1.5kΩ resistor between two pins of the device, done for all couples of pin combinations with other pins floating.
7. Machine model: 200pF is charged to the specified voltage, then discharged directly between two pins of the device with no external series resistor (internal resistor < 5Ω), done for all couples of pin combinations with other pins floating.
8. Charged device model: all pins plus package are charged together to the specified voltage and then discharged directly to the ground.

Table 2. Operating conditions

Symbol	Parameter	Value	Unit
V_{CC}	Supply voltage	2.5 to 5.5	V
V_{icm}	Common mode input voltage range	V_{DD} -0.1 to V_{CC} +0.1	V
T_{oper}	Operating free air temperature range	-40 to +125	°C

2 Electrical characteristics

Table 3. Electrical characteristics at V_{CC} = +2.5V, V_{DD} = 0V, V_{icm} = V_{CC}/2, T_{amb}= 25°C, R_L connected to V_{CC}/2 (unless otherwise specified)

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
DC performance						
V_{io}	Offset voltage TSV99x		-	0.1	4.5	mV
		$T_{min} < T_{op} < T_{max}$	-	-	7.5	
	TSV99xA		-	-	1.5	
		$T_{min} < T_{op} < T_{max}$	-	-	3	
DV_{io}	Input offset voltage drift		-	2	-	µV/°C
I_{io}	Input offset current(1) (V_{out} = V_{CC}/2)		-	1	10	pA
I_{ib}	Input bias current(1) (V_{out} = V_{CC}/2)		-	1	10	pA
CMR	Common mode rejection ratio 20 log ($\Delta V_{ic}/\Delta V_{io}$)	0V to 2.5V, V_{out} = 1.25V	58	75	-	dB
A_{vd}	Large signal voltage gain	R_L= 10kΩ, V_{out}= 0.5V to 2V	80	89	-	dB
V_{CC}-V_{OH}	High level output voltage	R_L = 10kΩ R_L = 600Ω		15 45	40 150	mV
V_{OL}	Low level output voltage	R_L = 10kΩ R_L = 600Ω	-	15 45	40 150	mV
I_{out}	I_{sink}	V_o = 2.5V	18	32	-	mA
		$T_{min} < T_{amb} < T_{max}$	16	-	-	
	I_{source}	V_o = 0V	18	35	-	
		$T_{min} < T_{amb} < T_{max}$	16	-	-	
I_{CC}	Supply current (per operator)	No load, V_{out}=V_{CC}/2	-	0.78	1.1	mA
		$T_{min} < T_{op} < T_{max}$	-	-	1.1	
AC performance						
GBP	Gain bandwidth product	R_L = 2kΩ, C_L = 100pF, f = 100kHz	-	20	-	MHz
ϕm	Phase margin	R_L = 2kΩ, C_L = 100pF, G=5, f=100kHz	-	60	-	Degrees
G_m	Gain margin	R_L = 2kΩ, C_L = 100pF, ϕm=40°	-	2.5	-	dB
SR	Slew rate	R_L = 2kΩ, C_L = 100pF	-	10	-	V/µs
e_n	Equivalent input noise voltage	f=10kHz	-	21	-	$\frac{nV}{\sqrt{Hz}}$
THD+e_n	Total harmonic distortion	G=1, f=1kHz, Rl=2kΩ, BW=22kHz, Vicm=(Vcc+1)/2, Vout=1.1Vpp	-	0.0017	-	%

1. Guaranteed by design.

Table 4. Electrical characteristics at V_{CC} = +3.3V, V_{DD} = 0V, V_{icm} = V_{CC}/2, T_{amb}= 25°C, R_L connected to V_{CC}/2 (unless otherwise specified)

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
DC performance						
V_{io}	Offset voltage TSV99x		-	0.1	4.5	mV
		$T_{min} < T_{op} < T_{max}$	-	-	7.5	
	TSV99xA		-	-	1.5	
		$T_{min} < T_{op} < T_{max}$	-	-	3	
DV_{io}	Input offset voltage drift		-	2	-	µV/°C
I_{io}	Input offset current(1)		-	1	10	pA
I_{ib}	Input bias current(1)		-	1	10	pA
CMR	Common mode rejection ratio 20 log ($\Delta V_{ic}/\Delta V_{io}$)	0V to 3.3V, V_{out} = 1.65V	60	78	-	dB
A_{vd}	Large signal voltage gain	R_L=10kΩ, V_{out}= 0.5V to 2.8V	80	90	-	dB
V_{CC}-V_{OH}	High level output voltage	R_L = 10kΩ R_L = 600Ω		15 45	40 150	mV
V_{OL}	Low level output voltage	R_L = 10kΩ R_L = 600Ω	-	15 45	40 150	mV
I_{out}	I_{sink}	V_o = 3.3V	18	32	-	mA
		$T_{min} < T_{amb} < T_{max}$	16	-	-	
	I_{source}	V_o = 0V	18	35	-	
		$T_{min} < T_{amb} < T_{max}$	16	-	-	
I_{CC}	Supply current (per operator)	No load, V_{out}=V_{CC}/2	-	0.8	1.1	mA
		$T_{min} < T_{op} < T_{max}$	-	-	1.1	
AC performance						
GBP	Gain bandwidth product	R_L = 2kΩ, C_L = 100pF, f = 100kHz	-	20	-	MHz
ϕm	Phase margin	R_L = 2kΩ, C_L = 100pF, G=5	-	60	-	Degrees
G_m	Gain margin	R_L = 2kΩ, C_L = 100pF, f = 100kHz, ϕm=40°	-	2.5	-	dB
SR	Slew rate	R_L = 2kΩ, C_L = 100pF, f = 100kHz	-	10	-	V/µs
e_n	Equivalent input noise voltage	f=10kHz	-	21	-	$\frac{nV}{\sqrt{Hz}}$
THD+e_n	Total harmonic distortion	G=1, f=1kHz, RI=2kΩ, BW=22kHz, Vicm=(Vcc+1)/2, Vout=1.9Vpp	-	0.001	-	%

1. Guaranteed by design.

Table 5. Electrical characteristics at V_{CC} = +5V, V_{DD} = 0V, V_{icm} = V_{CC}/2, T_{amb} = 25°C, R_L connected to V_{CC}/2 (unless otherwise specified)

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
DC performance						
V_{io}	Offset voltage TSV99x		-	0.1	4.5	mV
		$T_{min} < T_{op} < T_{max}$	-	-	7.5	
	TSV99xA		-	-	1.5	
		$T_{min} < T_{op} < T_{max}$	-	-	3	
DV_{io}	Input offset voltage drift		-	2	-	µV/°C
I_{io}	Input offset current(1)		-	1	10	pA
I_{ib}	Input bias current(1)		-	1	10	pA
CMR	Common mode rejection ratio 20 log ($\Delta V_{ic}/\Delta V_{io}$)	0V to 5V, V_{out} = 2.5V	62	82	-	dB
SVR	Supply voltage rejection ratio 20 log ($\Delta V_{cc}/\Delta V_{io}$)	V_{CC} = 2.5 to 5V	70	86	-	dB
A_{vd}	Large signal voltage gain	R_L=10kΩ, V_{out}= 0.5V to 4.5V	80	91	-	dB
V_{CC}-V_{OH}	High level output voltage	R_L = 10kΩ R_L = 600Ω		15 45	40 150	mV
V_{OL}	Low level output voltage	R_L = 10kΩ R_L = 600Ω	-	15 45	40 150	mV
I_{out}	I_{sink}	V_o = 5V	18	32	-	mA
		$T_{min} < T_{amb} < T_{max}$	16	-	-	
	I_{source}	V_o = 0V	18	35	-	
		$T_{min} < T_{amb} < T_{max}$	16	-	-	
I_{CC}	Supply current (per operator)	No load, V_{out}=2.5V	-	0.82	1.1	mA
		$T_{min} < T_{op} < T_{max}$	-	-	1.1	
AC performance						
GBP	Gain bandwidth product	R_L = 2kΩ, C_L = 100pF, f = 100kHz	-	20	-	MHz
ϕm	Phase margin	R_L = 2kΩ, C_L = 100pF, G=5	-	60	-	Degrees
G_m	Gain margin	R_L = 2kΩ, C_L=100pF, ϕm=40°	-	2.5	-	dB
SR	Slew rate	R_L = 2kΩ, C_L = 100pF	-	10	-	V/µs
e_n	Equivalent input noise voltage	f=10kHz	-	21	-	$\frac{nV}{\sqrt{Hz}}$
THD+e_n	Total harmonic distortion	G=1, f=1kHz, Rl=2kΩ, BW=22kHz, Vicm=(Vcc+1)/2, Vout=3.6Vpp	-	0.0007	-	%

1. Guaranteed by design.

Figure 1. Input offset voltage distribution at T=25°C

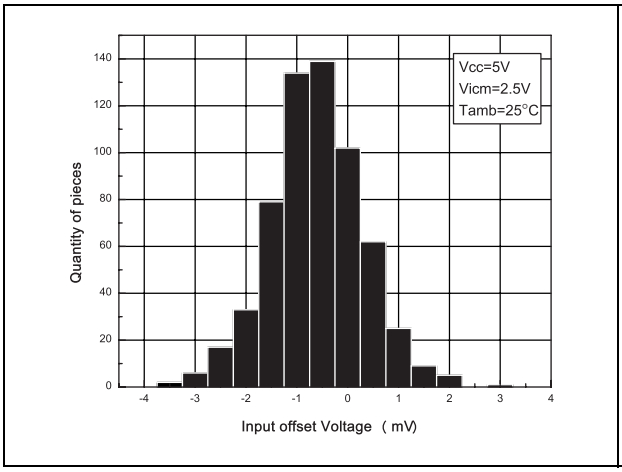


Figure 2. Input offset voltage distribution at T=125°C

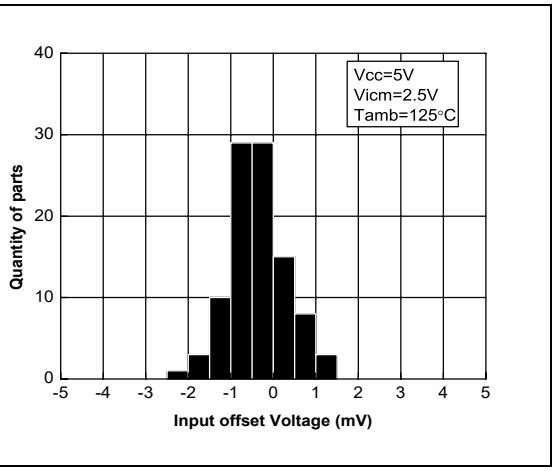


Figure 3. Supply current vs. input common mode voltage at V_{CC}=2.5V

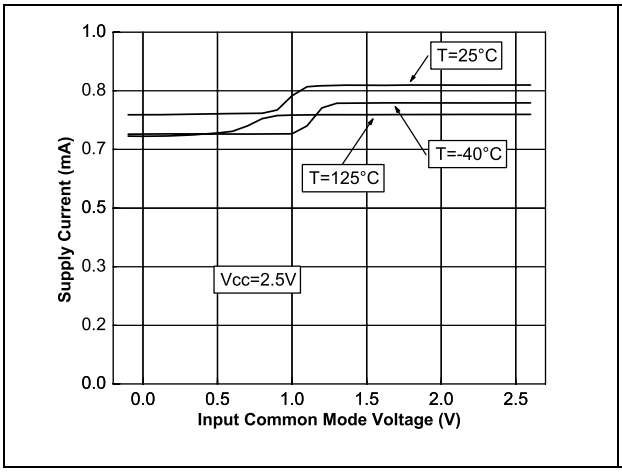


Figure 4. Supply current vs. input common mode voltage at V_{CC}=5V

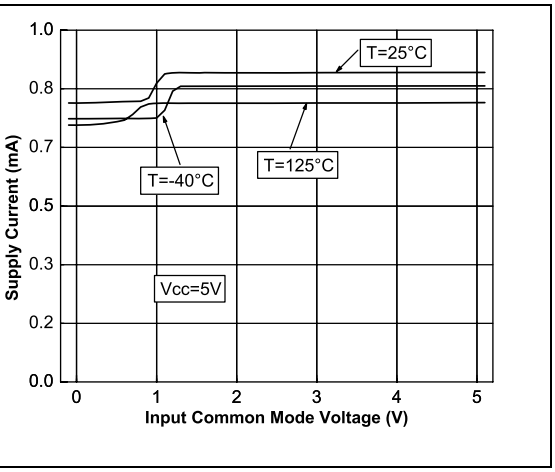


Figure 5. Output current vs. output voltage at V_{CC}=2.5V

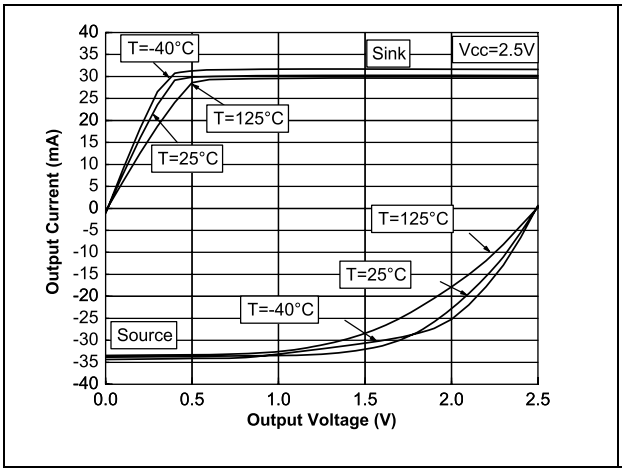


Figure 6. Output current vs. output voltage at V_{CC}=5V

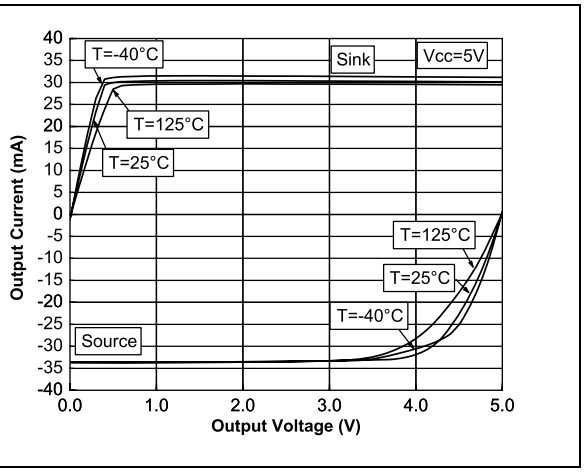


Figure 7. Voltage gain and phase vs frequency at V_{CC}=5V and V_{icm}=0.5V

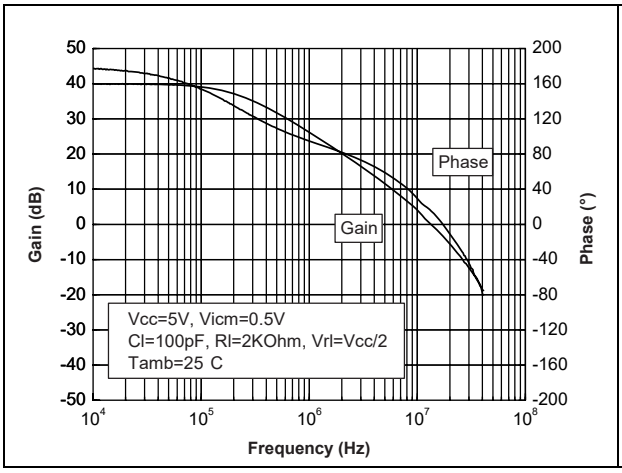


Figure 8. Voltage gain and phase vs frequency at V_{CC}=5V and V_{icm}=2.5V

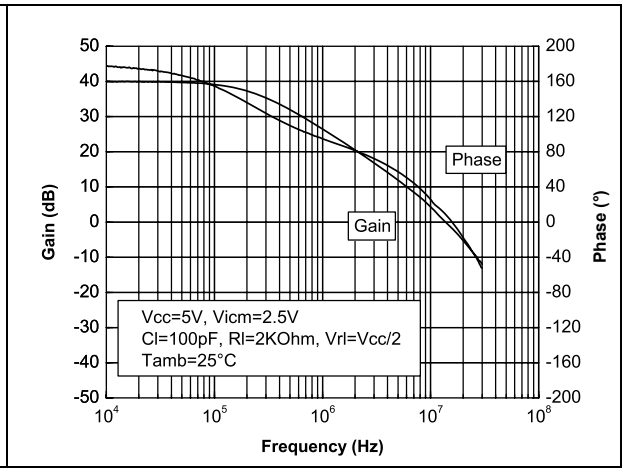


Figure 9. Positive slew rate

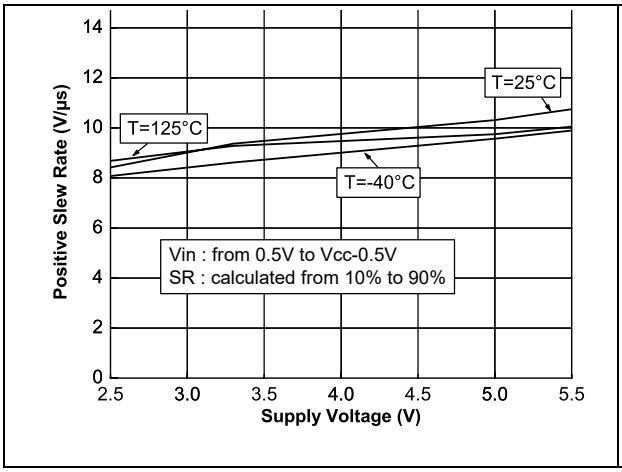


Figure 10. Negative slew rate

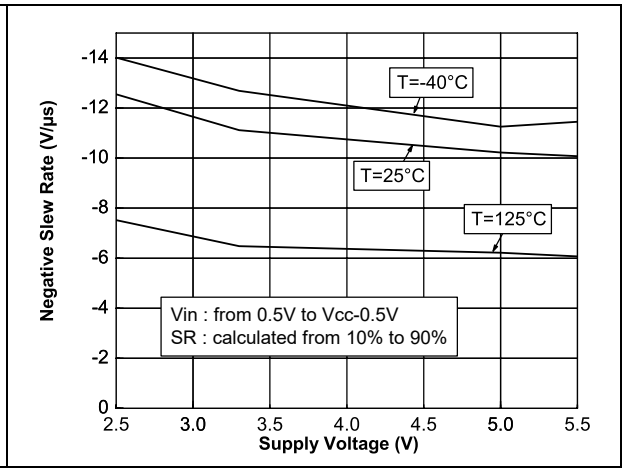


Figure 11. Distortion + noise vs. frequency

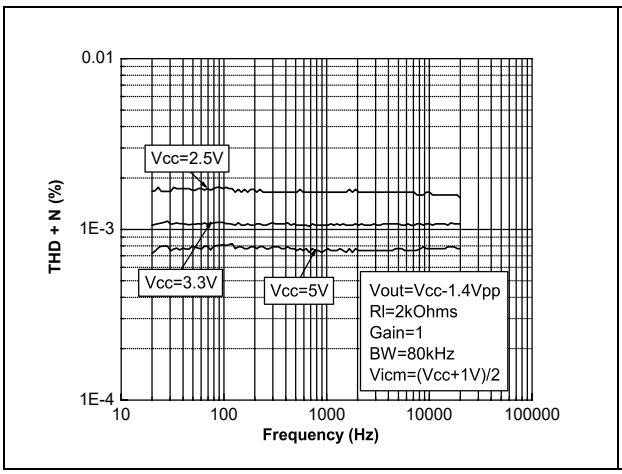


Figure 12. Distortion + noise vs. output voltage

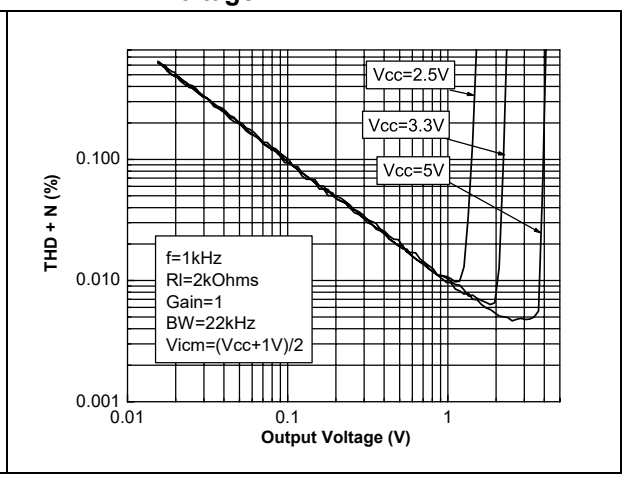
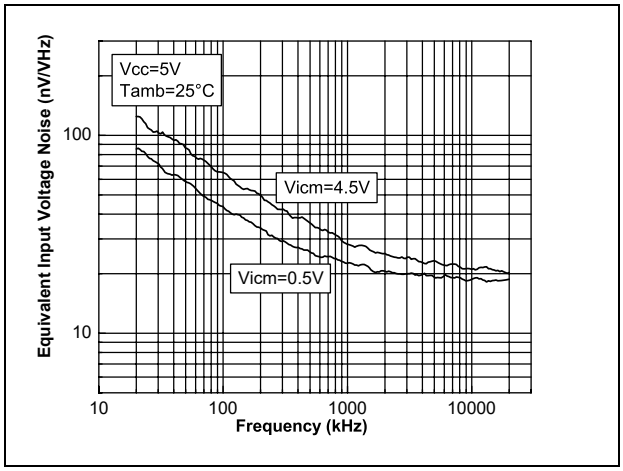


Figure 13. Noise vs. frequency



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.

Figure 14. SOT23-5 package

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

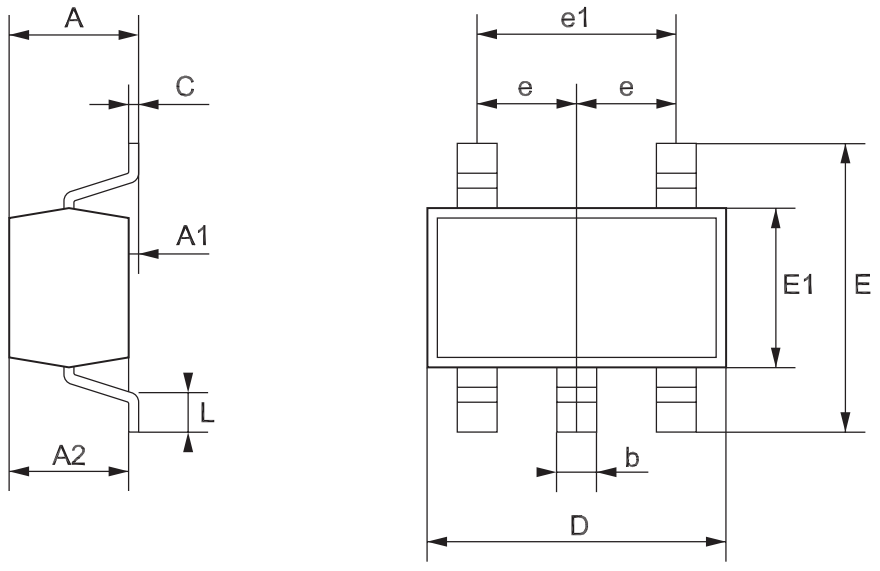


Figure 15. MiniSO-8 package

Ref.	Dimensions					
	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.1			0.043
A1	0.05	0.10	0.15	0.002	0.004	0.006
A2	0.78	0.86	0.94	0.031	0.034	0.037
b	0.25	0.33	0.40	0.010	0.013	0.016
c	0.13	0.18	0.23	0.005	0.007	0.009
D	2.90	3.00	3.10	0.114	0.118	0.122
E	4.75	4.90	5.05	0.187	0.193	0.199
E1	2.90	3.00	3.10	0.114	0.118	0.122
e		0.65			0.026	
K	0°		6°	0°		6°
L	0.40	0.55	0.70	0.016	0.022	0.028
L1			0.10			0.04

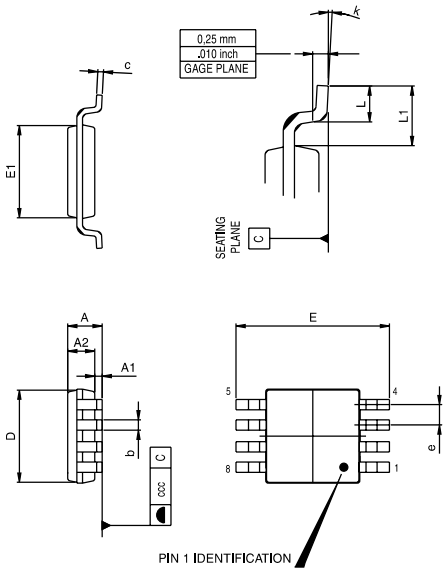


Figure 16. SO-8 package

Ref.	Dimensions					
	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A	1.35		1.75	0.053		0.069
A1	0.10		0.25	0.04		0.010
A2	1.10		1.65	0.043		0.065
B	0.33		0.51	0.013		0.020
C	0.19		0.25	0.007		0.010
D	4.80		5.00	0.189		0.197
E	3.80		4.00	0.150		0.157
e		1.27			0.050	
H	5.80		6.20	0.228		0.244
h	0.25		0.50	0.010		0.020
L	0.40		1.27	0.016		0.050
k	8° (max.)					
ddd			0.1			0.04

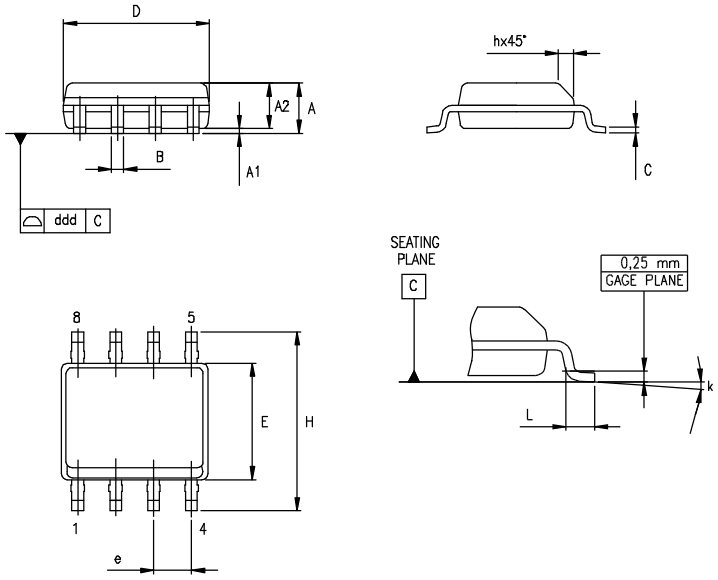


Figure 17. TSSOP14 package

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

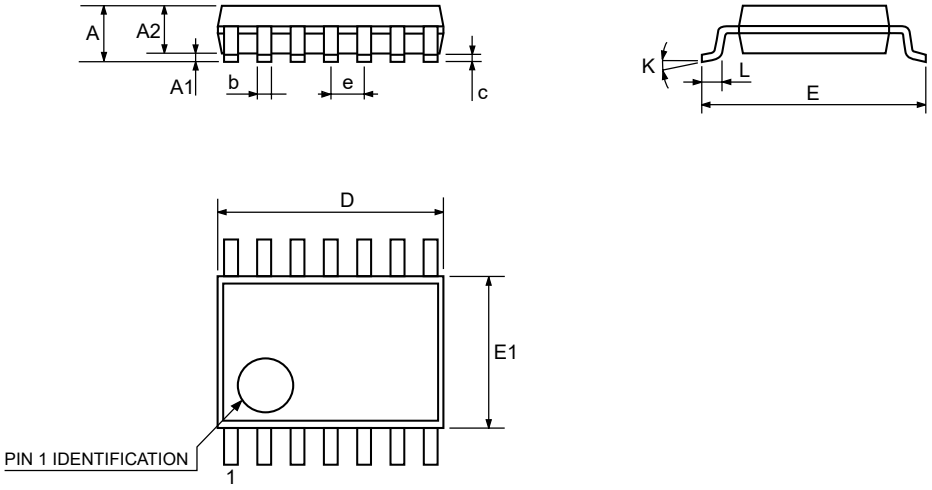
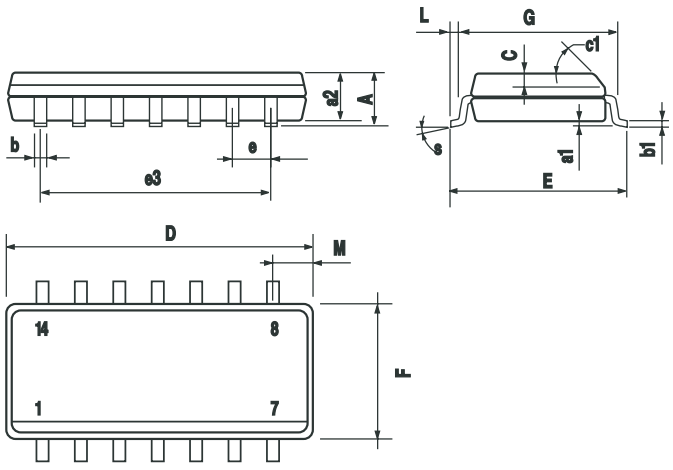


Figure 18. SO-14 package

Ref.	Dimensions					
	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.75			0.068
a1	0.1		0.2	0.003		0.007
a2			1.65			0.064
b	0.35		0.46	0.013		0.018
b1	0.19		0.25	0.007		0.010
C		0.5			0.019	
c1	45° (typ.)					
D	8.55		8.75	0.336		0.344
E	5.8		6.2	0.228		0.244
e		1.27			0.050	
e3		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° (max.)					



4 Ordering information

Part number	Temperature range	Package	Packing	Marking
TSV991ILT	-40°C to +125°C	SOT23-5	Tape & reel	K130
TSV991AILT				K129
TSV992IST		MiniSO-8		K132
TSV992AIST				K135
TSV992ID TSV992IDT		SO-8	Tube or tape & reel	V992I
TSV992AID TSV992AIDT				V992AI
TSV994IPT		TSSOP14	Tape & reel	V994I
TSV994AIPT				V994AI
TSV994ID TSV994IDT		SO-14	Tube or tape & reel	V994I
TSV994AID TSV994AIDT				V994AI

5 Revision history

Date	Revision	Changes
31-Jul-2006	1	Preliminary data release for product under development.
7-Nov-2006	2	Final version of datasheet.
12-Dec-2006	3	Noise and distortion figures added.