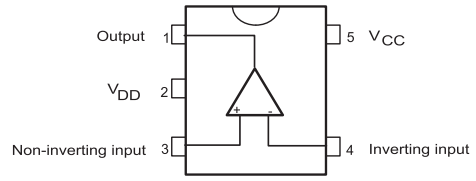
TS971, TS972, TS974

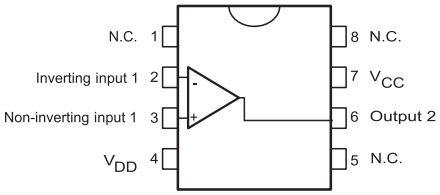
Output rail-to-rail very low noise operational amplifier

Datasheet - production data

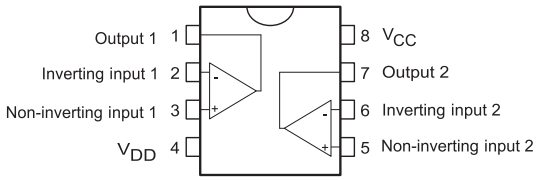
SOT23-5



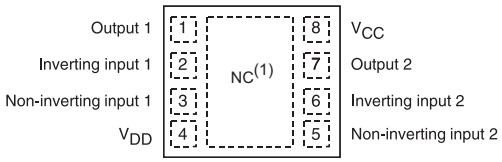
SO8



SO8, TSSOP8

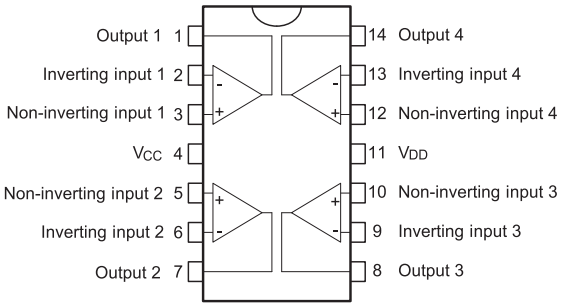


DFN8 3x3



(1) The exposed pads of DFN8 3x3 can be connected to VCC or left floating

SO14, TSSOP14



Features

- Rail-to-rail output voltage swing ±2.4 V at V_{CC} = ±2.5 V
- Very low noise level: 4 nV/√Hz
- Ultra low distortion: 0.003 %
- High dynamic features: 12 MHz, 4 V/µs
- Operating range: 2.7 to 10 V
- ESD protection (2 kV)
- Latch-up immunity (class A)

Applications

- Portable devices (CD players, PDAs)
- Portable communication (cell phones, pagers)
- Instrumentation and sensing tehnology
- Professional audio circuits

Description

The TS97x family of operational amplifiers operate with voltages as low as ±1.35 V and feature output rail-to-rail signal swing. The TS97x devices are particularly well suited for portable and battery supplied equipment. Very low noise and low distortion characteristics make them ideal for audio pre-amplification.

The TS97x devices are available in a variety of packages to suit all types of applications. For applications where space saving is critical, the SOT23-5 package (2.8 x 2.9 mm) or the DFN8 package (3 x 3 mm) simplify the board design because they can be placed anywhere on it.

Contents

1 Absolute maximum ratings and operating conditions

Table 1. Absolute maximum ratings (AMR)

Symbol	Parameter	Value	Unit
V_{CC}	Supply voltage(1)	12	V
V_{id}	Differential input voltage(2)	±1	
V_{in}	Input voltage(3)	V_{DD} -0.3 to V_{CC} +0.3	
T_{stg}	Storage temperature range	-65 to +150	°C
T_j	Maximum junction temperature	150	
R_{thja}	Thermal resistance junction-to-ambient(4) SOT23-5 SO8 TSSOP8 DFN8 3x3 SO14 TSSOP14	 250 125 120 40 105 100	°C/W
R_{thjc}	Thermal resistance junction-to-case(4) SOT23-5 SO8 TSSOP8 DFN8 3x3 SO14 TSSOP14	 81 40 37 5.2 31 32	
ESD	HBM: human body model(5)	2	kV
	MM: machine model(6)	200	V
	CDM: charged device model(7)	1.5	kV
	Lead temperature (soldering, 10 sec.)	260	°C

1. All voltage values, except differential voltage are with respect to network ground terminal.
2. The differential voltage is the non-inverting input terminal with respect to the inverting input terminal.
3. The magnitude of input and output voltages must never exceed V_{CC} +0.3 V.
4. Short-circuits can cause excessive heating and destructive dissipation. Values are typical.
5. Human body model: a 100 pF capacitor is charged to the specified voltage, then discharged through a 1.5kΩ resistor between two pins of the device. This is done for all couples of connected pin combinations while the other pins are floating.
6. 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.
7. Charged device model: all pins and package are charged together to the specified voltage and then discharged directly to ground through only one pin. This is done for all pins.

   No value specified for CDM on SOT23-5 package.

Table 2. Operating conditions

Symbol	Parameter	Value	Unit
V_{CC}	Supply voltage	2.7 to 10	V
V_{icm}	Common mode input voltage range	V_{DD} +1.15 to V_{CC} -1.15	
T_{oper}	Operating free air temperature range	-40 to +125	°C

2 Electrical characteristics

Table 3. Electrical characteristics at V_{CC} = +2.5 V, V_{DD} = -2.5 V, T_{amb} = 25 °C (unless otherwise specified)

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
V_{io}	Input offset voltage	$T_{min} \le T_{amb} \le T_{max}$		1	5 7	mV
$\Delta V_{io}/\Delta T$	Input offset voltage drift	V_{icm} = 0 V, V_o = 0 V		5		µV/°C
I_{io}	Input offset current	V_{icm} = 0 V, V_o = 0 V		10	150	nA
I_{ib}	Input bias current	V_{icm} = 0 V, V_o = 0 V $T_{min} \le T_{amb} \le T_{max}$		200 200	750 1000	
V_{icm}	Common mode input voltage range		-1.35		1.35	V
CMR	Common mode rejection ratio	V_{icm} = ±1.35 V	60	85		dB
SVR	Supply voltage rejection ratio	V_{CC} = ±2 V to ±3 V	60	70		
A_{vd}	Large signal voltage gain	R_L = 2 kΩ	70	80		
V_{OH}	High level output voltage		2	2.4		V
V_{OL}	Low level output voltage			-2.4	-2	
I_{source}	Output source current			1.5		mA
I_{sink}	Output sink current			100		
I_{CC}	Supply current per amplifier	Unity gain - no load		2	2.8	
GBP	Gain bandwidth product	f = 100 kHz, R_L = 2 kΩ, C_L = 100 pF	8.5	12		MHz
SR	Slew rate	A_V = 1, V_{in} = ±1 V	2.8	4		V/µs
∅m	Phase margin at unit gain	R_L = 2 kΩ, C_L = 100 pF		60		Degrees
Gm	Gain margin			10		dB
e_n	Equivalent input noise voltage	f = 100 kHz		4		nV/√Hz
i_n	Equivalent input noise current	f = 1 kHz		250		fA/√Hz
THD	Total harmonic distortion	f = 1 kHz, A_V = -1, R_L = 10 kΩ		0.003		%

Figure 1. Input offset voltage distribution

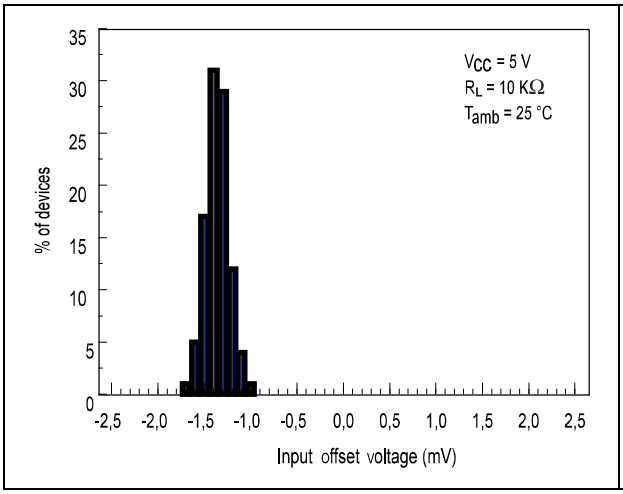


Figure 2. Voltage gain and phase vs. frequency V_{CC} = 5 V

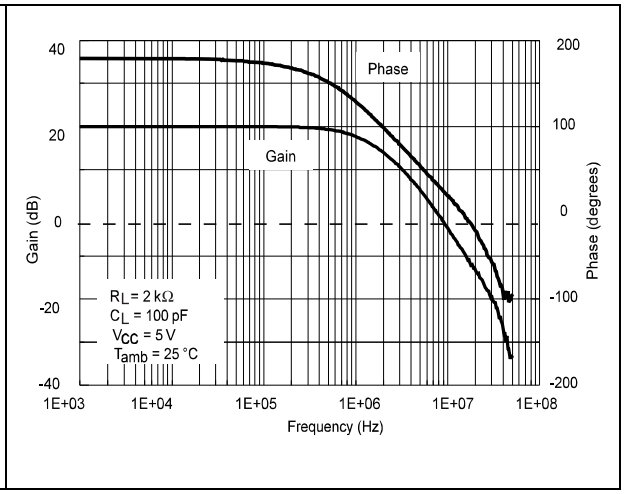


Figure 3. Voltage gain and phase vs. frequency V_{CC} = 2.7 V

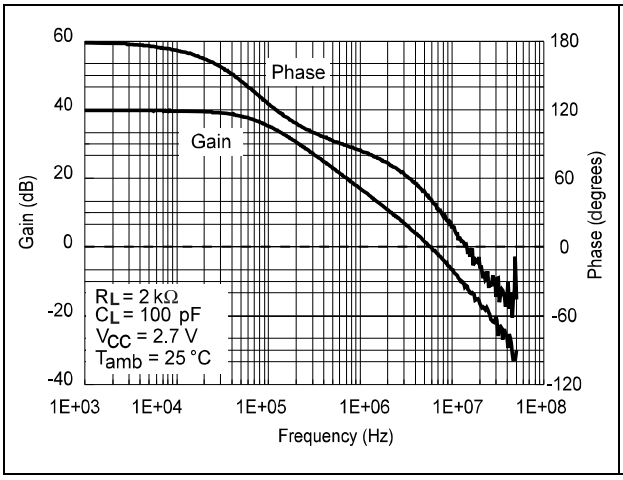


Figure 4. THS vs. V_{out}, V_{CC} = 5 V

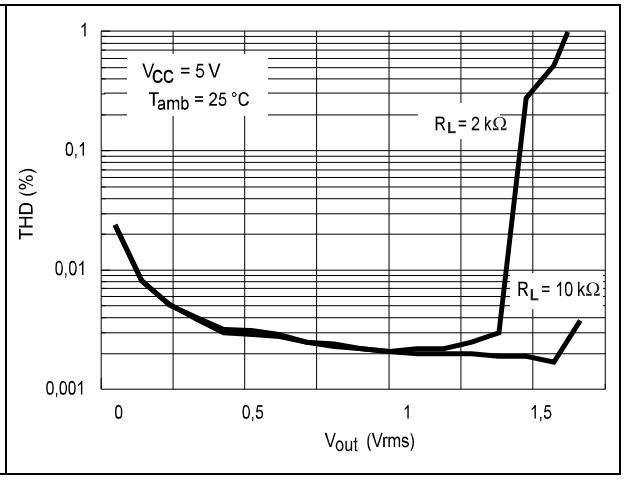


Figure 5. THD vs. V_{out}, V_{CC} = 2.7 V

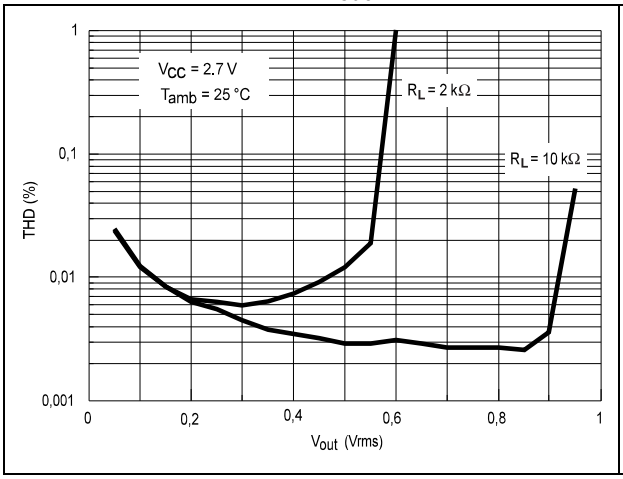


Figure 6. THD vs. frequency

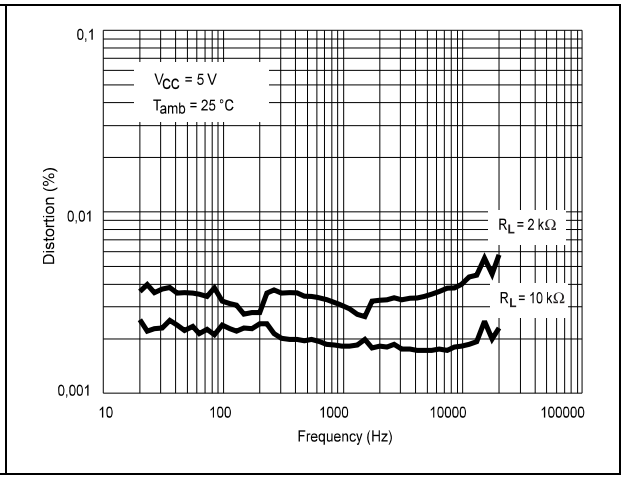


Figure 7. Noise voltage vs. frequency

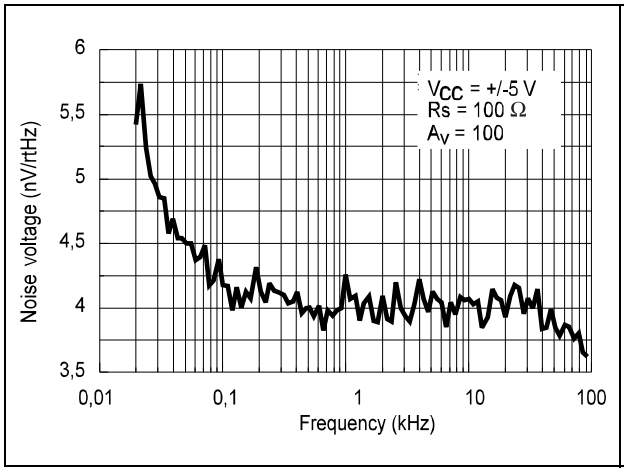


Figure 8. Gain bandwidth product vs. I_{out}

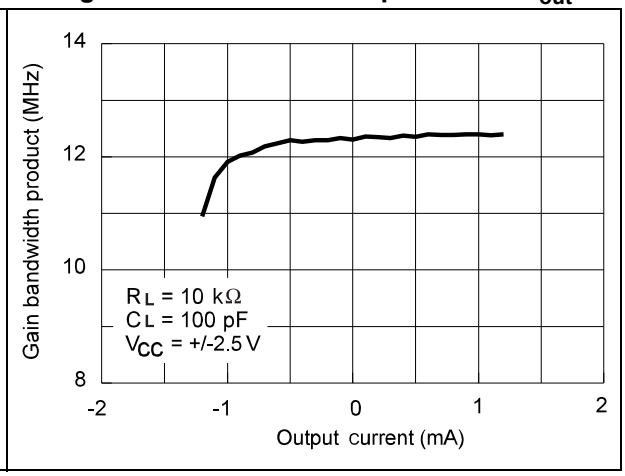


Figure 9. Phase margin vs. I_{out}

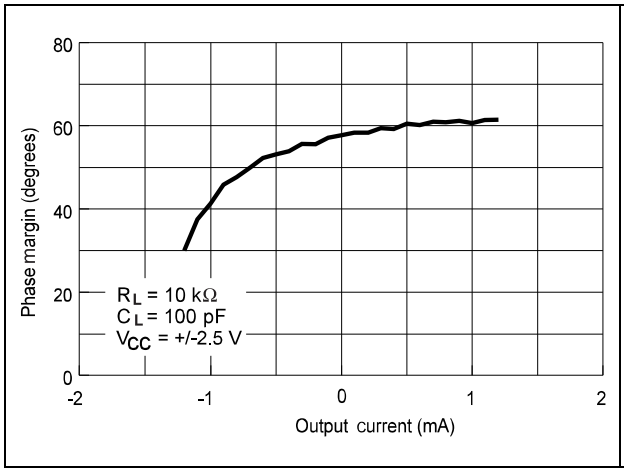


Figure 10. Phase margin vs. V_{CC} R_L = 10 k, C_L = 30 pF

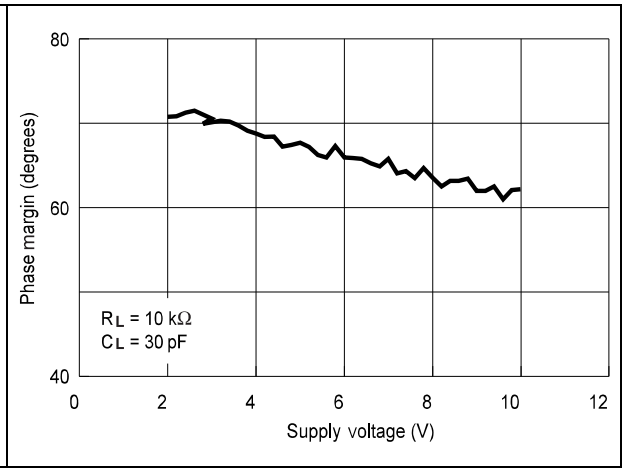


Figure 11. Phase margin vs. V_{CC} C_L = 30, 130 and 250 pF

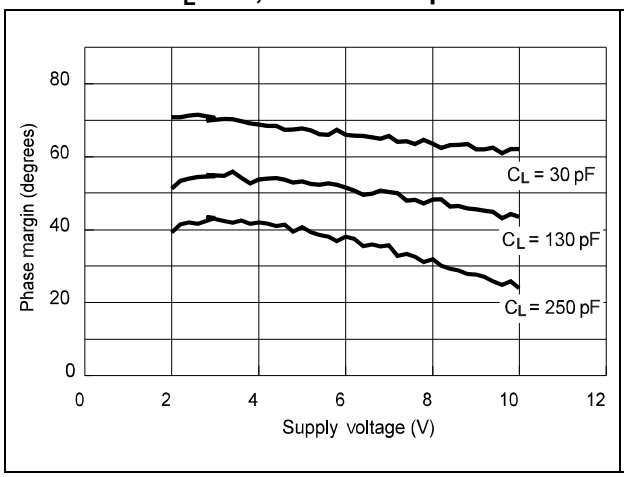
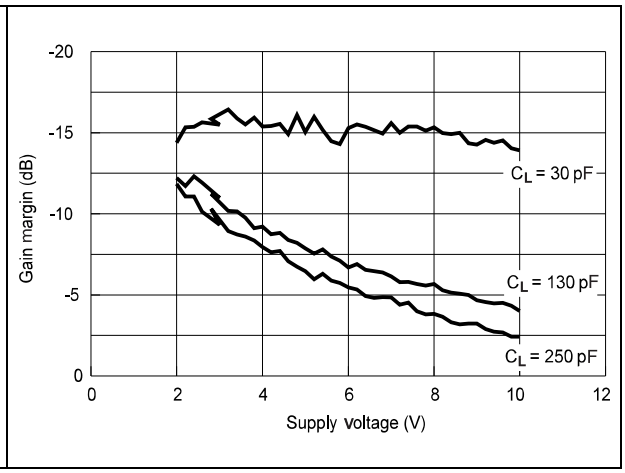


Figure 12. Gain margin vs. V_{CC}



3 Package information

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK® packages, depending on their level of environmental compliance. ECOPACK specifications, grade definitions and product status are available at: *www.st.com*. ECOPACK is an ST trademark.

3.1 SOT23-5 package information

Figure 13. SOT23-5 package outline

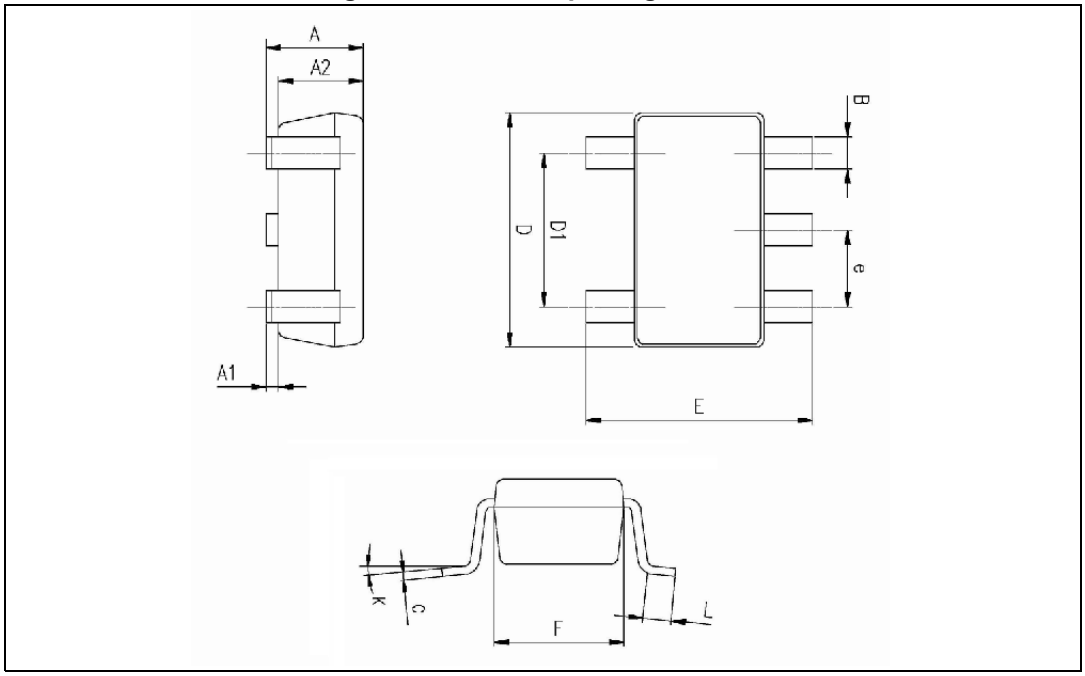


Table 4. SOT23-5 package mechanical data

Symbol	Dimensions					
	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A	0.90	1.20	1.45	0.035	0.047	0.057
A1			0.15			0.006
A2	0.90	1.05	1.30	0.035	0.041	0.051
B	0.35	0.40	0.50	0.013	0.015	0.019
C	0.09	0.15	0.20	0.003	0.006	0.008
D	2.80	2.90	3.00	0.110	0.114	0.118
D1		1.90			0.075	
e		0.95			0.037	
E	2.60	2.80	3.00	0.102	0.110	0.118
F	1.50	1.60	1.75	0.059	0.063	0.069
L	0.10	0.35	0.60	0.004	0.013	0.023
K	0 °		10 °	0 °		10 °

3.2 SO8 package information

Figure 14. SO8 package outline

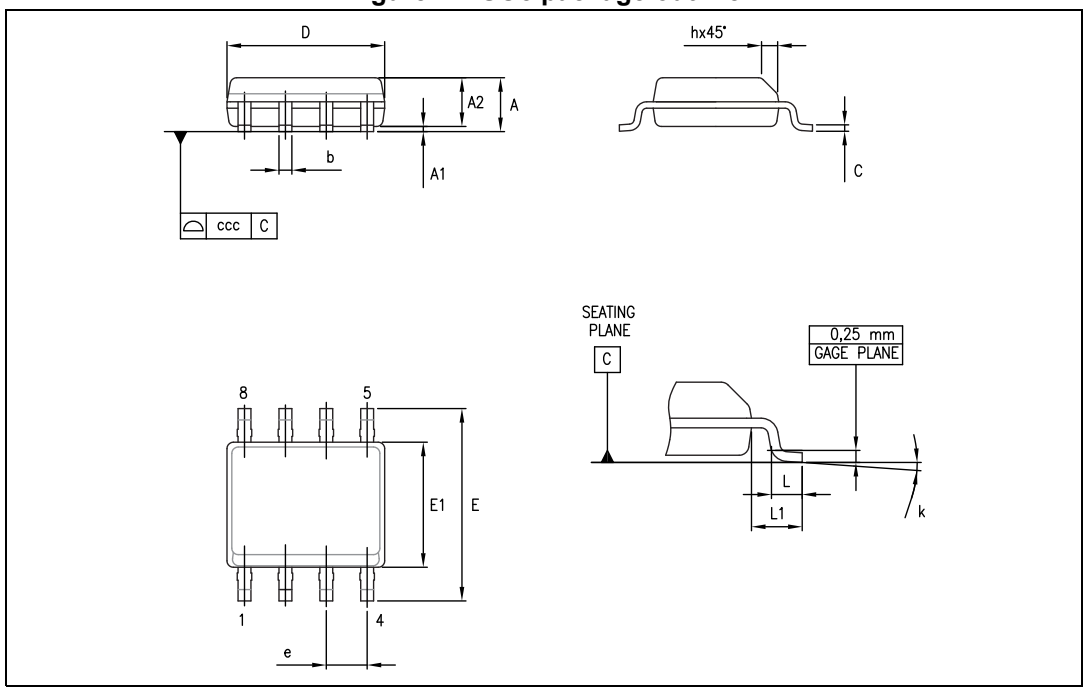


Table 5. SO8 package mechanical data

Symbol	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
L1		1.04			0.040	
k	0 °		8 °	1 °		8 °
ccc			0.10			0.004

3.3 TSSOP8 package information

Figure 15. TSSOP8 package outline

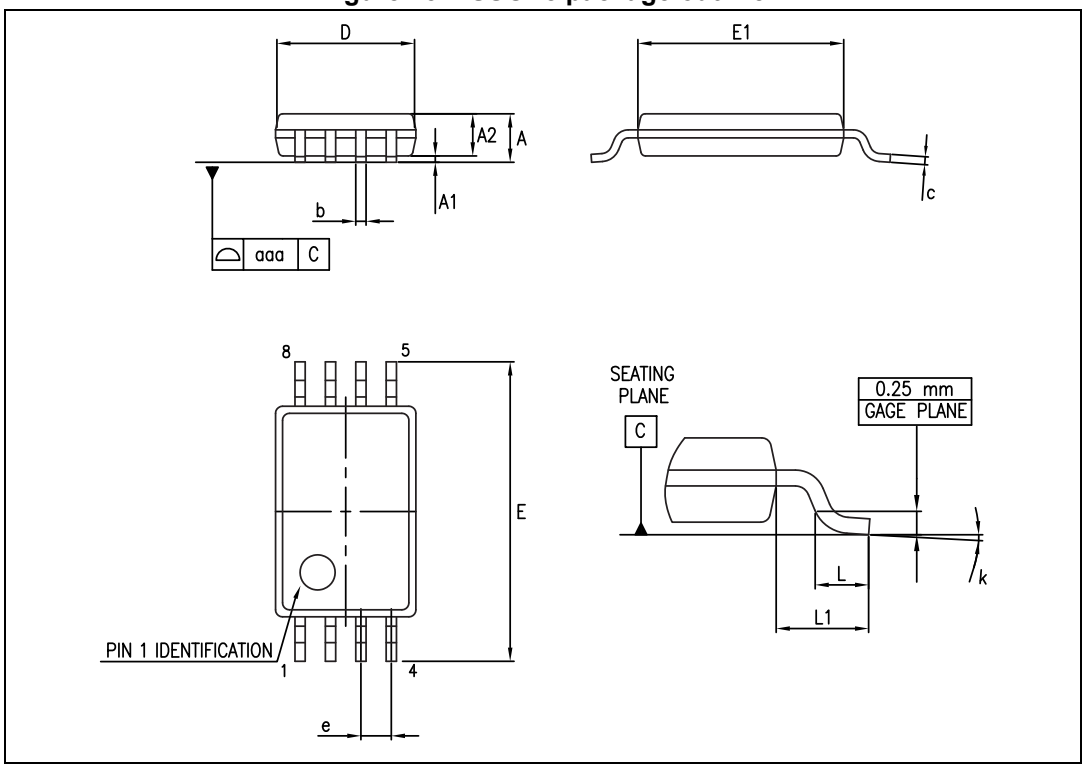


Table 6. TSSOP8 package mechanical data

Symbol	Dimensions					
	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.20			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		1.00			0.039	
aaa			0.10			0.004

3.4 DFN8 3x3 exposed pad package information

Figure 16. DFN8 3x3 exposed pad package outline (pitch 0.5 mm)

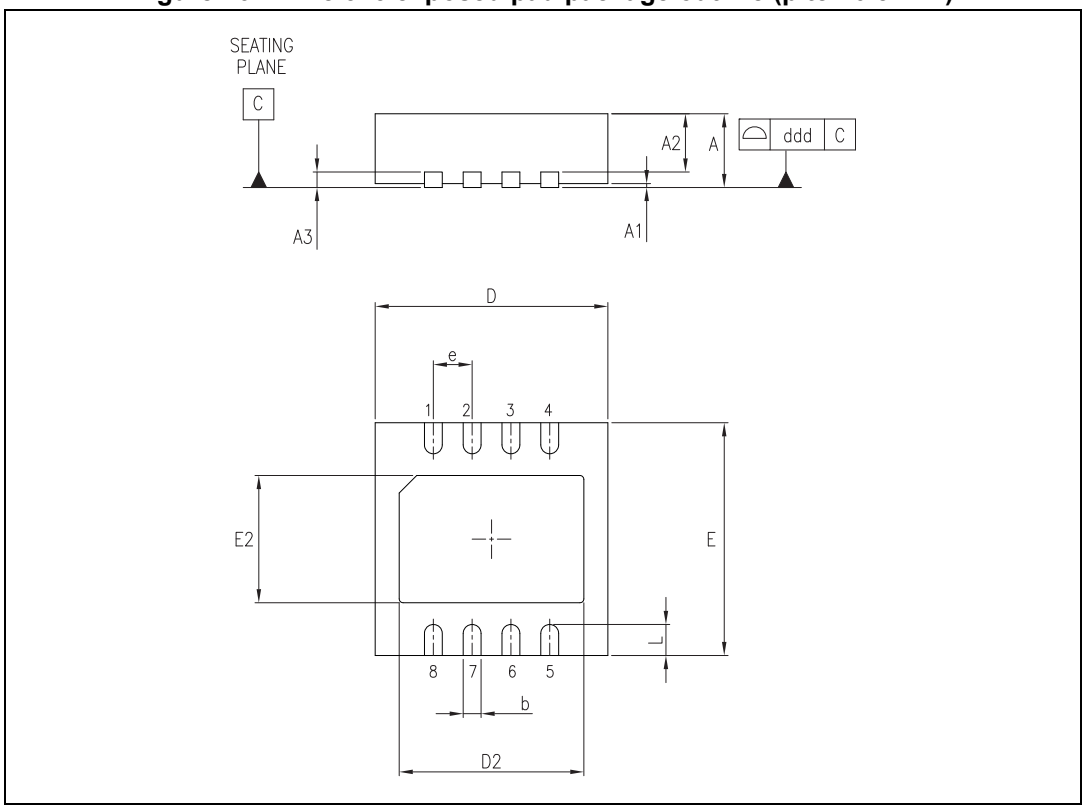


Table 7. DFN8 3x3 mm exposed pad package mechanical data (pitch 0.5 mm)

Symbol	Dimensions					
	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A	0.80	0.90	1.00	0.031	0.035	0.039
A1		0.02	0.05		0.0008	0.0019
A2	0.55	0.65	0.80	0.021	0.025	0.031
A3		0.20			0.008	
b	0.18	0.25	0.30	0.007	0.010	0.012
D	2.85	3.00	3.15	0.112	0.118	0.124
D2	2.20		2.70	0.087		0.106
E	2.85	3.00	3.15	0.112	0.118	0.124
E2	1.40		1.75	0.055		0.069
e		0.50			0.020	
L	0.30	0.40	0.50	0.012	0.016	0.020
ddd			0.08			0.003

3.5 SO14 package information

Figure 17. SO14 package outline

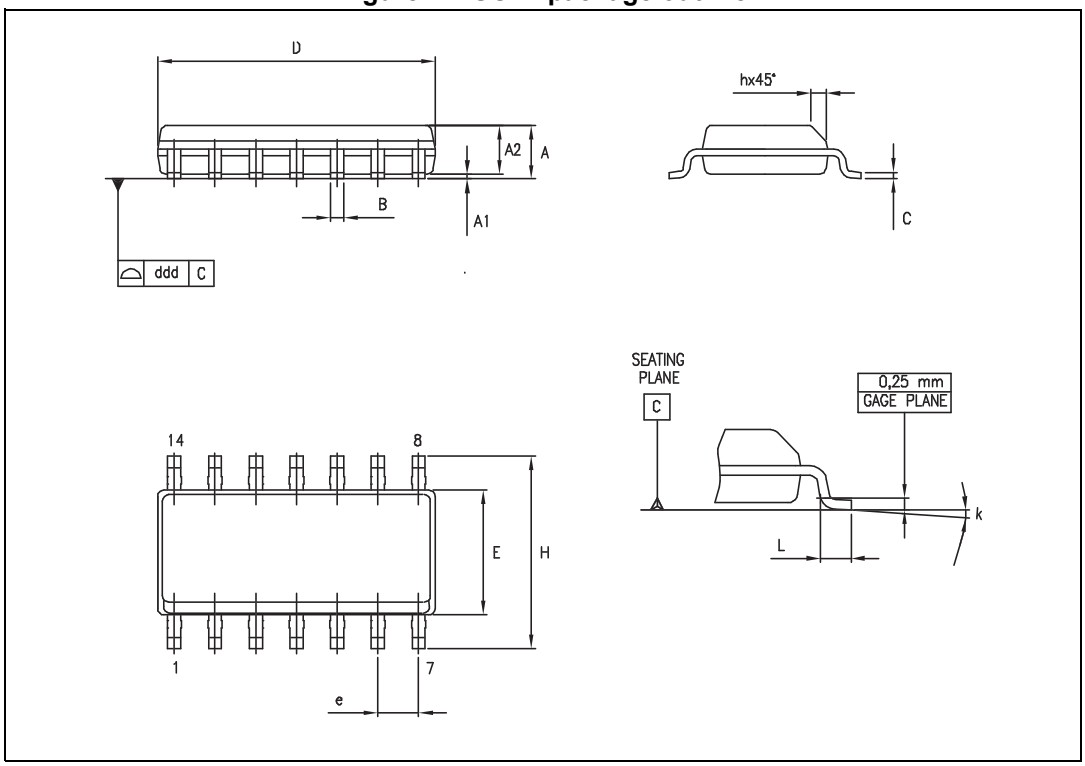


Table 8. SO14 package mechanical data

Symbol	Dimensions					
	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A	1.35		1.75	0.05		0.068
A1	0.10		0.25	0.004		0.009
A2	1.10		1.65	0.04		0.06
B	0.33		0.51	0.01		0.02
C	0.19		0.25	0.007		0.009
D	8.55		8.75	0.33		0.34
E	3.80		4.0	0.15		0.15
e		1.27			0.05	
H	5.80		6.20	0.22		0.24
h	0.25		0.50	0.009		0.02
L	0.40		1.27	0.015		0.05
k	8 ° (max.)					
ddd			0.10			0.004

3.6 TSSOP14 package information

Figure 18. TSSOP14 package outline

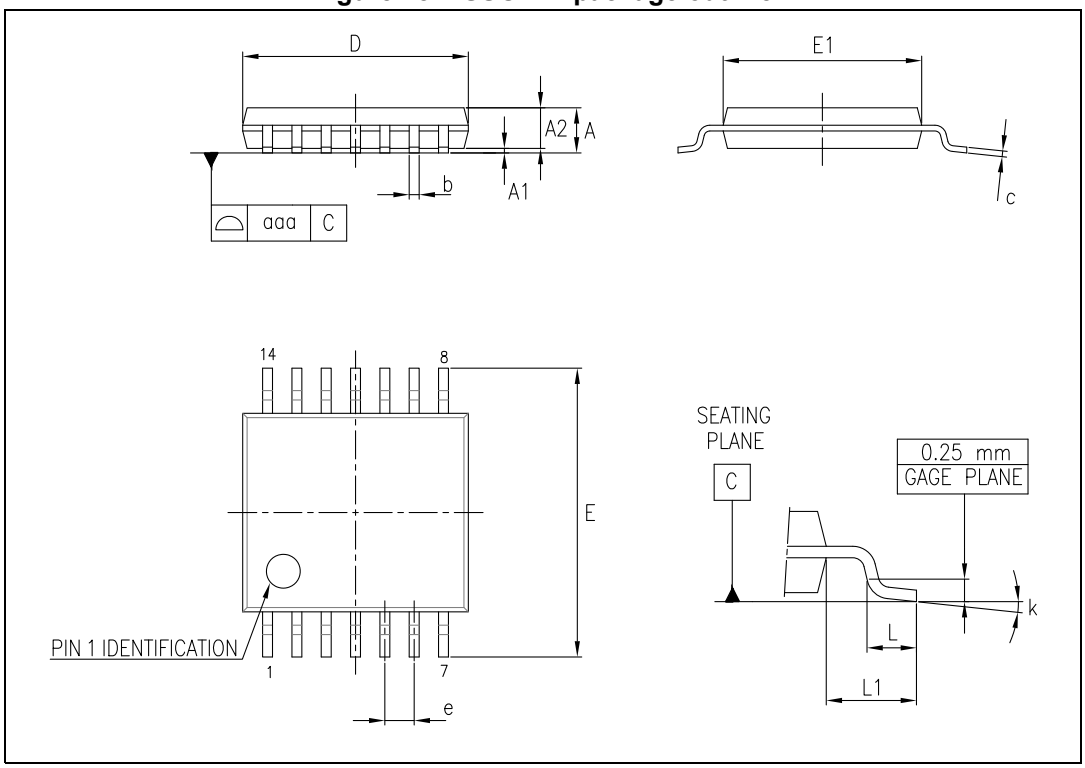


Table 9. TSSOP14 package mechanical data

Symbol	Dimensions					
	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.20			0.047
A1	0.05		0.15	0.002	0.004	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		0.0089
D	4.90	5.00	5.10	0.193	0.197	0.201
E	6.20	6.40	6.60	0.244	0.252	0.260
E1	4.30	4.40	4.50	0.169	0.173	0.176
e		0.65			0.0256	
L	0.45	0.60	0.75	0.018	0.024	0.030
L1		1.00			0.039	
k	0 °		8 °	0 °		8 °
aaa			0.10			0.004

4 Ordering information

Table 10. Order codes

Order code	Temperature range	Package	Packaging	Marking
TS971IDT	-40 °C, +125 °C	SO8	Tube or tape and reel	971I
TS971ILT		SOT23-5	Tape and reel	K120
TS971IYLT(1)		SOT23-5 (automotive grade level)		K121
TS972IDT		SO8	Tube or tape and reel	972I
TS972IPT		TSSOP8 (thin shrink outline package)	Tape and reel	
TS972IQT		DFN8 3x3 (dual micro lead frame package)		
TS972IYDT(1)		SO8 (automotive grade level)	Tube or tape and reel	972IY
TS972IYPT(1)		TSSOP8 (automotive grade level)	Tape and reel	972IY
TS974IDT		SO14	Tube or tape and reel	974I
TS974IPT		TSSOP14 (thin shrink outline package)	Tape and reel	
TS974IYDT(1)		SO14 (automotive grade level)		974IY
TS974IYPT(1)		TSSOP14 (automotive grade level)		974IY

1. Qualified and characterized according to AEC Q100 and Q003 or equivalent, advanced screening according to AEC Q001 and Q 002 or equivalent.

5 Revision history

Table 11. Document revision history

Date	Revision	Changes
15-Nov- 2002	1	First release.
9-May- 2005	2	Modifications on AMR table (explanation of V_{id} and V_i limits)
31-Aug-2005	3	PPAP references inserted in the datasheet, see Table 1 on page 2.
9-Dec-2005	4	Thermal resistance junction to case data added in *Table 1. on page 3* Missing PPAP references inserted in the datasheet, see *Table 10: Order codes*.
3-Oct-2007	5	Added R_{thja} and R_{thjc} values for DIP8 and DIP14 packages in *Table 1*. ESD footnotes updated in *Table 1: Absolute maximum ratings (AMR)*. Description section updated on cover page. Markings for automotive grade parts corrected in *Table 10: Order codes*.
20-Dec-2007	6	Reformatted package information in *Section 3: Package information*. Footnotes for automotive grade parts corrected in *Table 10: Order codes*.
06-May-2010	7	Updated package information (drawings and data) in *Chapter 3*. Removed DIP package order codes from *Chapter 4: Ordering information*.
19-Sep-2012	8	Updated “Pin connection” figure on page 1 (removed part numbers). Removed TS971ID, TS971IYD, TS972ID, TS972IYD, TS974ID and TS974IYD order code from *Table 10*. Qualified status of TS971IYLT and TS974IYPT order code in *Table 10*. Minor corrections throughout document.
19-Jul-2013	9	Added footnote regarding NC to the DFN8 3x3 pinout *Table 10: Order codes*: removed order code TS971IYDT; added automotive qualification to order code TS972IYPT.
07-Mar-2014	10	*Table 3: Electrical characteristics at V_{CC} = +2.5 V, V_{DD} = -2.5 V, T_{amb} = 25 °C (unless otherwise specified)*: added parameter “equivalent input noise current”

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