TS951-TS952-TS954

Input/output rail-to-rail low power operational amplifier

Features

- Rail-to-rail input common-mode voltage range
- Rail-to-rail output voltage swing
- Operating from 2.7V to 12V
- High-speed (3MHz, 1V/μs)
- Low consumption (0.9mA @ 3V)
- Supply voltage rejection ratio: 80dB
- Latch-up immunity
- Available in SOT23-5 micropackage

Applications

- Set-top boxes
- Laptop/notebook computers
- Transformer/line drivers
- Personal entertainment (CD players)
- Portable communications (cell phones, pagers)
- Instrumentation & sensoring
- Digital-to-analog converter buffers
- Portable headphone speaker drivers

Description

The TS95x family are rail-to-rail BiCMOS operational amplifiers optimized and fully specified for 3V and 5V operation.

The TS951 is housed in the space-saving 5-pin SOT23 package that makes it well suited for battery-powered systems. This micropackage simplifies the PC board design because of its ability to be placed in tight spaces (outside dimensions are: 2.8mm x 2.9mm).

TS951ILT

TS951ID

TS952IN-TS952ID-TS952IPT

TS954IN-TS954ID-TS954IPT
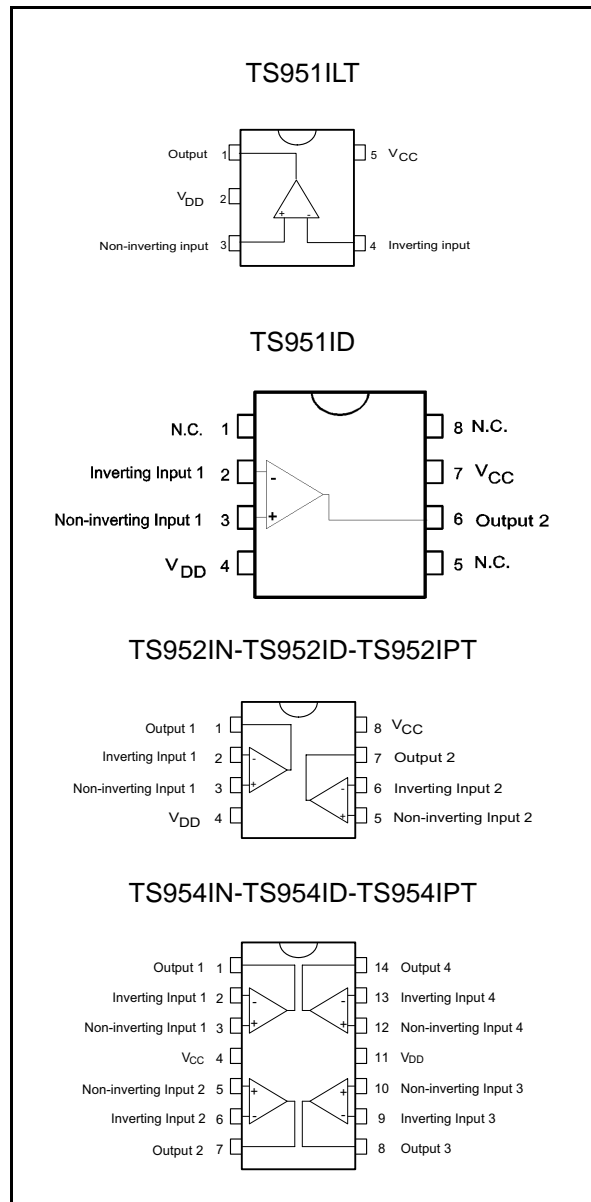
1 Absolute maximum ratings and operating conditions

Table 1.   Absolute maximum ratings (AMR)

Symbol	Parameter	Value	Unit
V_{CC}	Supply voltage [1]	14	V
V_{id}	Differential input voltage [2]	±1	V
V_{in}	Input voltage [3]	V_{DD}-0.3 to V_{CC}+0.3	V
T_{stg}	Storage temperature range	-65 to +150	
T_j	Maximum junction temperature	150	°C
R_{thja}	Thermal resistance junction to ambient [4] SOT23-5 SO-8 SO-14 TSSOP8 TSSOP14	250 125 103 120 100	°C/W
R_{thjc}	Thermal resistance junction to case [4] SOT23-5 SO-8 SO-14 TSSOP8 TSSOP14	81 40 31 37 32	°C/W
ESD	HBM: human body model[5] TS951 TS952 TS954	1 2 3	kV
	MM: machine model[6]	100	V
	CDM: charged device model[7] TS951 TS952 TS954	1.5 1.5 1	kV
	Latch-up immunity	200	mA
	Lead temperature (soldering, 10sec)	260	°C

1. All voltage values, except differential voltage are with respect to network ground terminal.

2. Differential voltages are the non-inverting input terminal with respect to the inverting input terminal.
    If $V_{id} > ±1V$, the maximum input current must not exceed ±1mA. In this case ($V_{id} > ±1V$), an input series resistor must be added to limit input current.

3. Do not exceed 14V.

4. Short-circuits can cause excessive heating and destructive dissipation. R_{th} are typical values.

5. Human body model: A 100pF 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 200pF capacitor is charged to the specified voltage, then discharged directly between two pins of the device with no external series resistor (internal resistor < 5Ω). This is done for all couples of connected pin combinations while the other pins are floating.

7. 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.

Table 2.   Operating conditions

Symbol	Parameter	Value	Unit
V_{CC}	Supply voltage	2.7 to 12	V
V_{icm}	Common mode input voltage range	V_{DD} -0.2 to V_{CC} +0.2	V
T_{oper}	Operating free air temperature range	-40 to +125	°C

2 Electrical characteristics

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

Symbol	Parameter	Min.	Typ.	Max.	Unit
V_{io}	Input offset voltage $T_{min} \leq T_{amb} \leq T_{max}$			6 8	mV
DV_{io}	Input offset voltage drift		2		µV/°C
I_{io}	Input offset current $T_{min} \leq T_{amb} \leq T_{max}$		1	30 80	nA
I_{ib}	Input bias current $V_{icm} = V_{CC}/2$ $T_{min} \leq T_{amb} \leq T_{max}$		35	100 200	nA
CMR	Common mode rejection ratio	50	80		dB
SVR	Supply voltage rejection ratio $V_{CC} = 2.7V$ to $3.3V$	60	80		dB
A_{vd}	Large signal voltage gain $V_o = 2V_{pk-pk}$, $R_L = 600\Omega$		80		dB
V_{OH}	High level output voltage $R_L = 600\Omega$	2.8	2.9		V
V_{OL}	Low level output voltage $R_L = 600\Omega$		80	250	mV
I_{sc}	Output short-circuit current	10			mA
I_{CC}	Supply current (per amplifier) No load, $V_{icm} = V_{CC}/2$		0.9	1.3	mA
GBP	Gain bandwidth product $R_L = 2k\Omega$		3		MHz
SR	Slew rate		1		V/µs
$\varnothing m$	Phase margin at unit gain $R_L = 600\Omega$, $C_L = 100pF$		60		Degrees
Gm	Gain margin $R_L = 600\Omega$, $C_L = 100pF$		10		dB
e_n	Equivalent input noise voltage $f = 1kHz$		25		$\frac{nV}{\sqrt{Hz}}$
THD	Total harmonic distortion $V_{out} = 4V_{pk-pk}$, $F = 10kHz$, $A_V = 2$, $R_L = 10k\Omega$		0.01		%

Table 4. V_{CC} = +5V, V_{DD} = 0V, R_L connected to V_{CC}/2, T_{amb} = 25°C (unless otherwise specified)

Symbol	Parameter	Min.	Typ.	Max.	Unit
V_{io}	Input offset voltage $T_{min} \leq T_{amb} \leq T_{max}$			6 8	mV
DV_{io}	Input offset voltage drift		2		µV/°C
I_{io}	Input offset current $V_{icm} = V_{CC}$/2 $T_{min} \leq T_{amb} \leq T_{max}$		1	30 80	nA
I_{ib}	Input bias current $V_{icm} = V_{CC}$/2 $T_{min} \leq T_{amb} \leq T_{max}$		35	100 200	nA
CMR	Common mode rejection ratio	50	80		dB
SVR	Supply voltage rejection ratio V_{CC} = 2.7V to 3.3V	60	80		dB
A_{vd}	Large signal voltage gain V_o = 2V_{pk-pk}, R_L = 600Ω		86		dB
V_{OH}	High level output voltage R_L = 600Ω	4.7	4.8		V
V_{OL}	Low level output voltage R_L = 600Ω		80	300	mV
I_{sc}	Output short-circuit current	10			mA
I_{CC}	Supply current (per amplifier) No load, $V_{icm} = V_{CC}$/2		0.95	1.4	mA
GBP	Gain bandwidth product R_L = 2kΩ		3		MHz
SR	Slew rate		1		V/µs
$\varnothing$m	Phase margin at unit gain R_L = 600Ω, C_L =100pF		60		Degrees
Gm	Gain margin R_L = 600Ω, C_L =100pF		10		dB
e_n	Equivalent input noise voltage f = 1kHz		25		$\frac{nV}{\sqrt{Hz}}$
THD	Total harmonic distortion V_{out} = 4V_{pk-pk}, F = 10kHz, A_V = 2, R_L =10kΩ		0.01		%

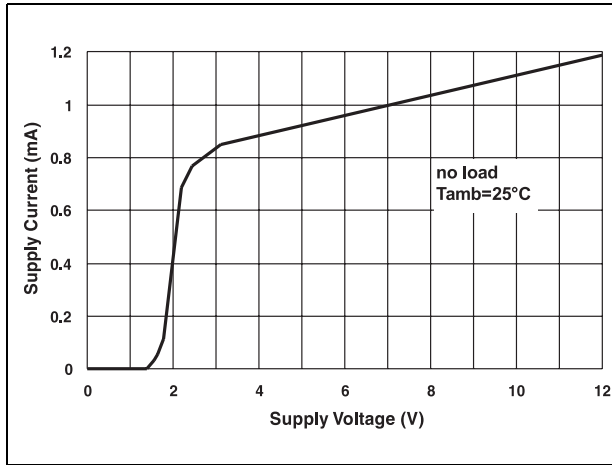**Figure 1.   Supply current vs. supply voltage**

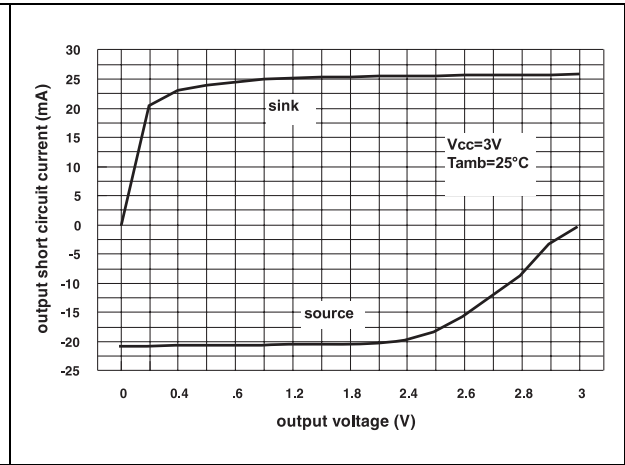**Figure 2.   Output short circuit current vs. output voltage**
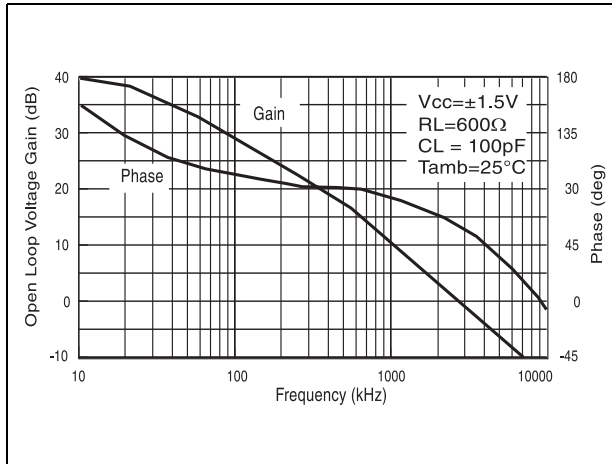

Figure 3.   Voltage gain and phase vs. frequency
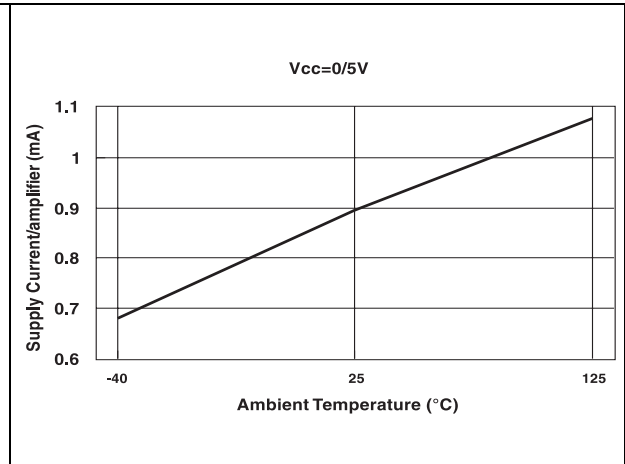

Figure 4.   Supply current vs. temperature

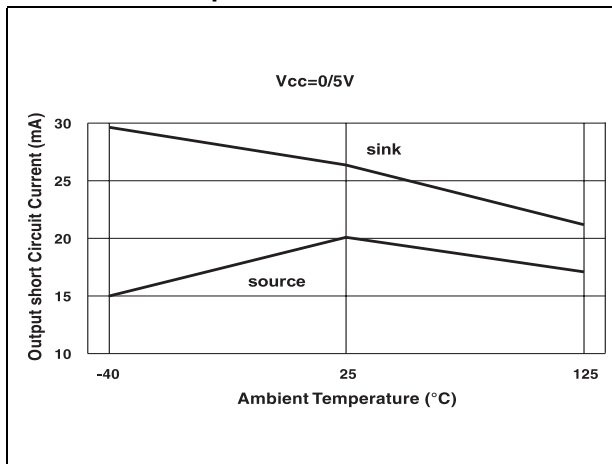**Figure 5.   Output short circuit current vs. temperature**

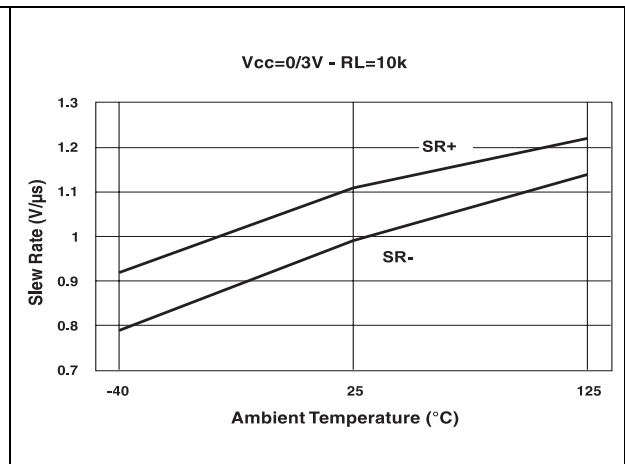**Figure 6.   Slew rate vs. temperature**
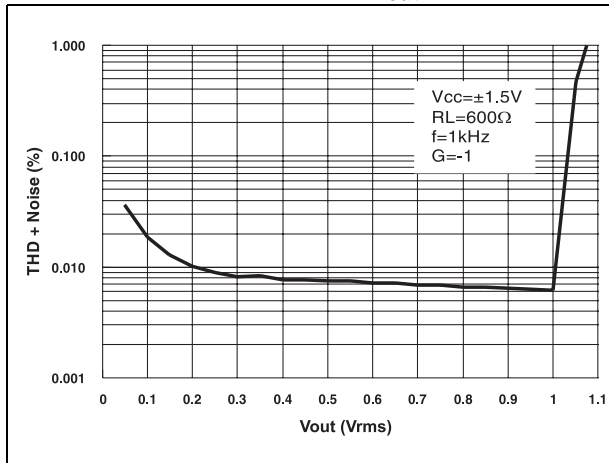
Figure 7.   THD + noise vs. V_out

Figure 8.   THD + noise vs. frequency
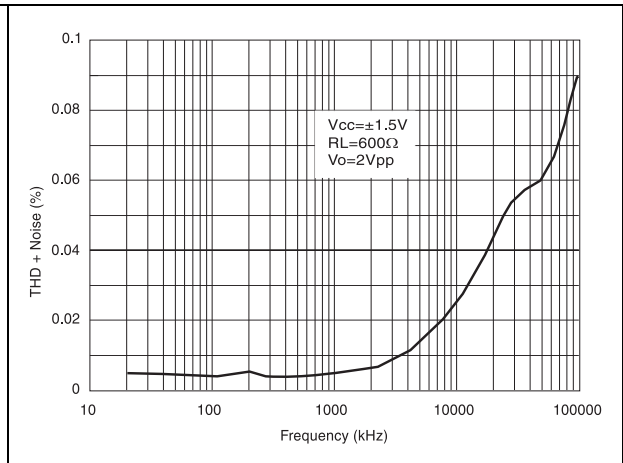

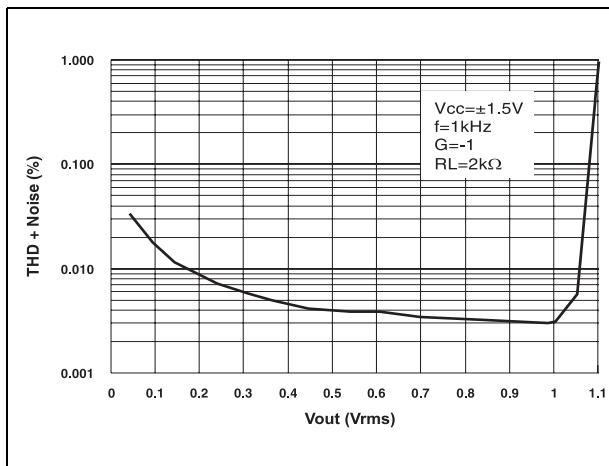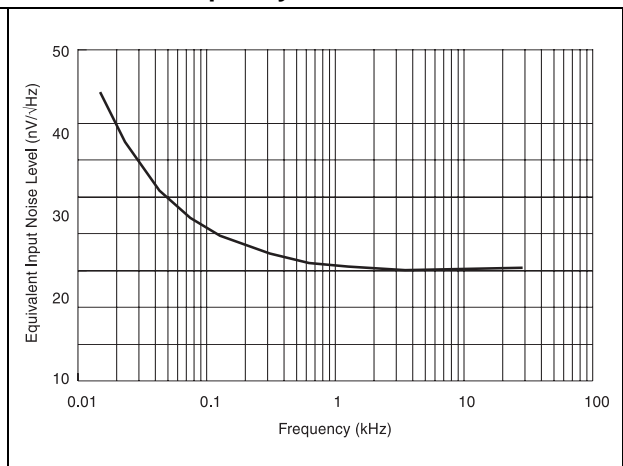**Figure 9.   THD + noise vs. V_out**

Figure 10.   Equivalent input noise voltage vs. frequency

3 Package information

In order to meet environmental requirements, ST 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 ST trademark. ECOPACK specifications are available at: www.st.com.

3.1 SOT23-5 package information

Figure 11. SOT23-5 package mechanical drawing
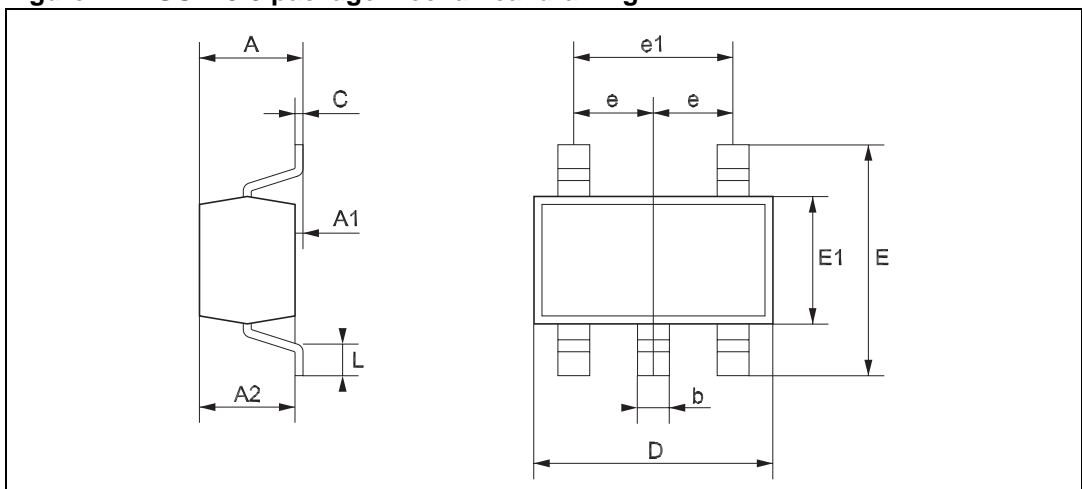
Table 5. SOT23-5 package mechanical data

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 DIP8 package information

Figure 12. DIP8 package mechanical drawing
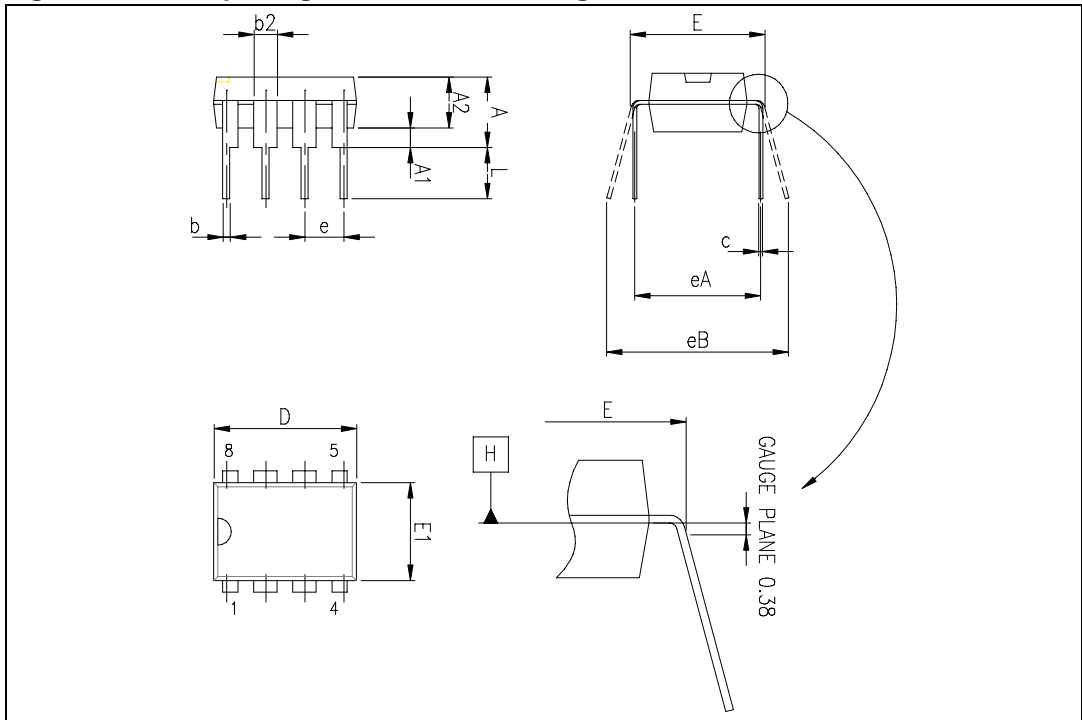
Table 6. DIP8 package mechanical data

Ref.	Dimensions					
	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			5.33			0.210
A1	0.38			0.015		
A2	2.92	3.30	4.95	0.115	0.130	0.195
b	0.36	0.46	0.56	0.014	0.018	0.022
b2	1.14	1.52	1.78	0.045	0.060	0.070
c	0.20	0.25	0.36	0.008	0.010	0.014
D	9.02	9.27	10.16	0.355	0.365	0.400
E	7.62	7.87	8.26	0.300	0.310	0.325
E1	6.10	6.35	7.11	0.240	0.250	0.280
e		2.54			0.100	
eA		7.62			0.300	
eB			10.92			0.430
L	2.92	3.30	3.81	0.115	0.130	0.150

3.3 SO-8 package information

Figure 13. SO-8 package mechanical drawing
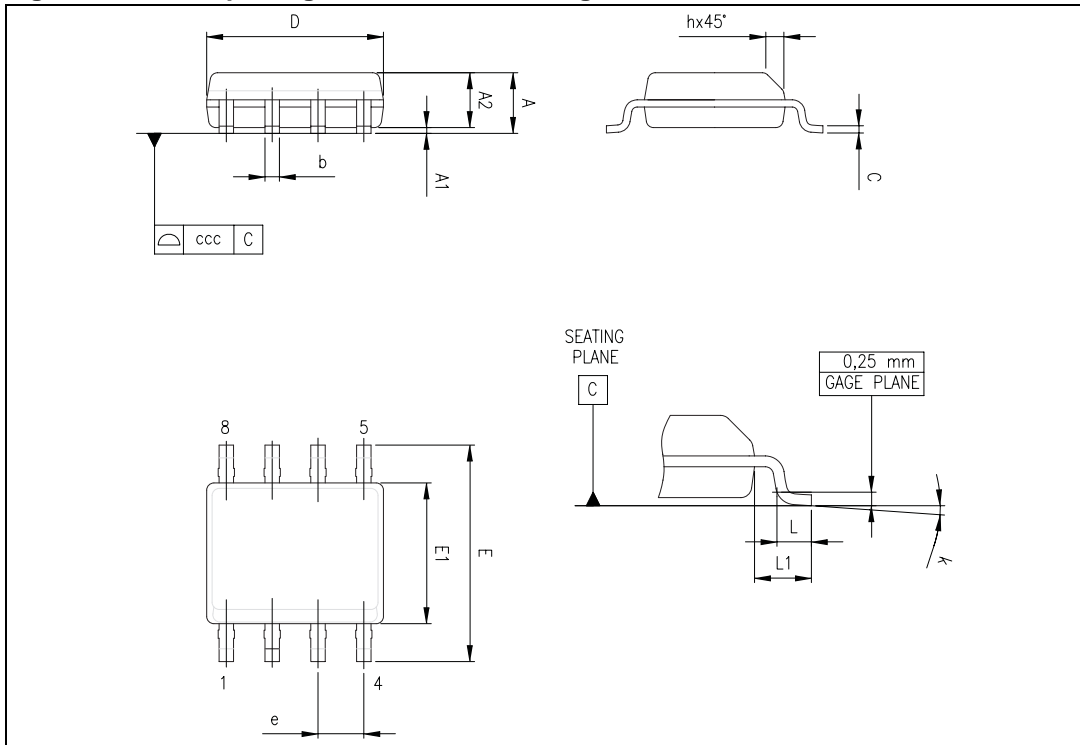
Table 7. SO-8 package mechanical data

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
H	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

3.4   TSSOP8 package information

Figure 14.   TSSOP8 package mechanical drawing
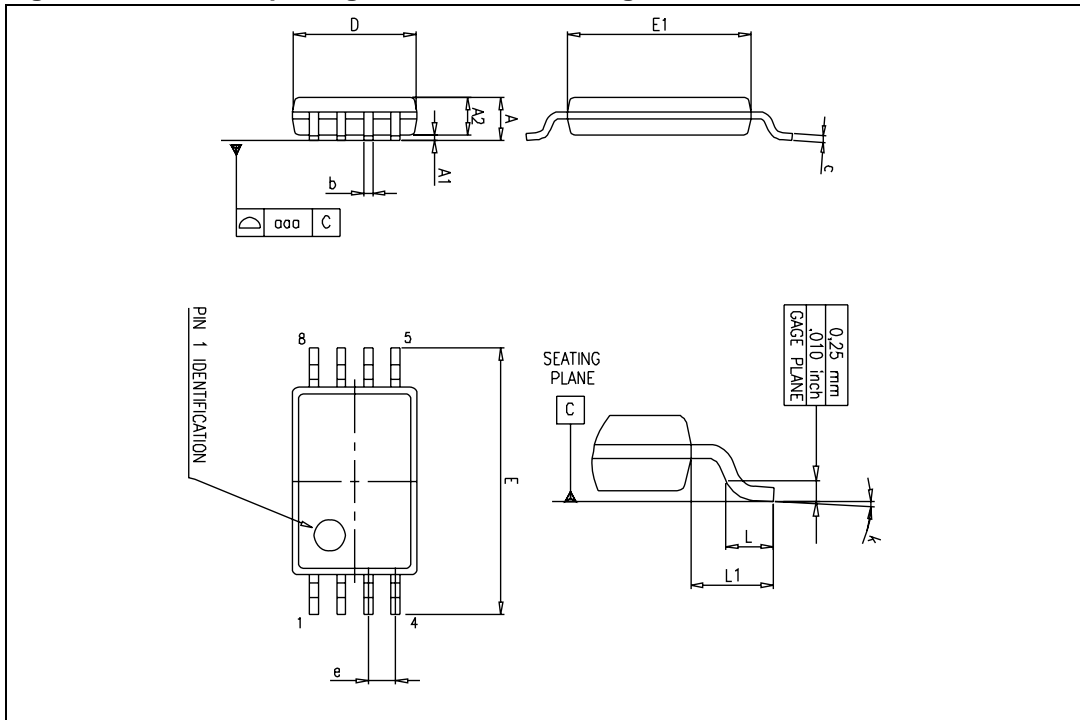
Table 8.   TSSOP8 package mechanical data

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	

3.5 DIP14 package information

Figure 15. DIP14 package mechanical drawing
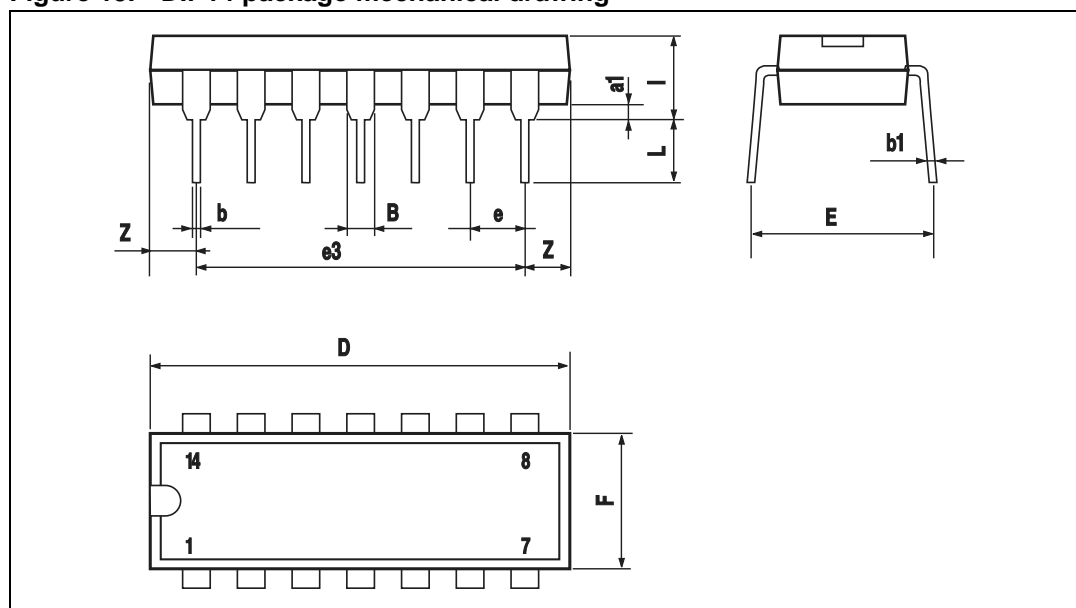
Table 9. DIP14 package mechanical data

Ref.	Dimensions					
	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
a1	0.51			0.020		
B	1.39		1.65	0.055		0.065
b		0.5			0.020	
b1		0.25			0.010	
D			20			0.787
E		8.5			0.335	
e		2.54			0.100	
e3		15.24			0.600	
F			7.1			0.280
I			5.1			0.201
L		3.3			0.130	
Z	1.27		2.54	0.050		0.100

3.6   SO-14 package information

Figure 16.   SO-14 package mechanical drawing
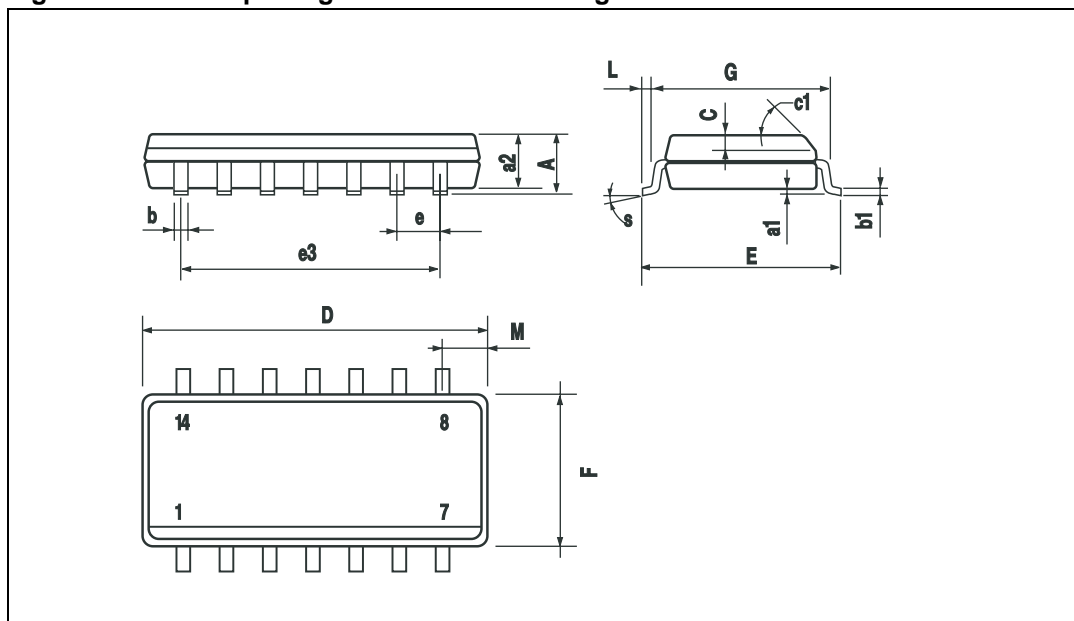
Table 10.   SO-14 package mechanical data

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.)					

3.7 TSSOP14 package information

Figure 17. TSSOP14 package mechanical drawing
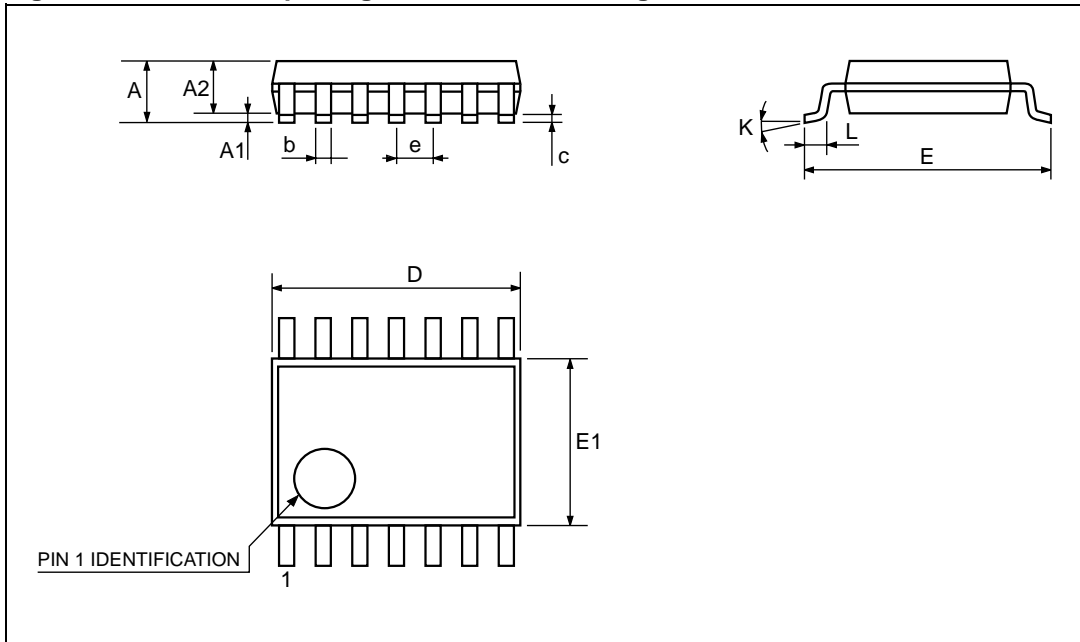
Table 11. TSSOP14 package mechanical data

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 12.   Order codes

Part number	Temperature range	Package	Packing	Marking
TS951IN	-40°C to +125°C	DIP8	Tube	TS951IN
TS951ID TS951IDT		SO-8	Tube or Tape & reel	951I
TS951ILT		SOT23-5L	Tape & reel	K101
TS951IYLT[1]		SOT23-5L (Automotive grade)		K102
TS952IN		DIP8	Tube	TS952IN
TS952ID TS952IDT		SO-8	Tube or Tape & reel	952I
TS952IYD[2] TS952IYDT[2]		SO-8 (Automotive grade)		952IY
TS952IPT		TSSOP8	Tape & reel	952I
TS952IYPT[1]		TSSOP8 (Automotive grade)		952Y
TS954IN		DIP14	Tube	TS954IN
TS954ID TS954IDT		SO-14	Tube or Tape & reel	954I
TS954IYD[2] TS954IYDT[2]		SO-14 (Automotive grade)		954IY
TS954IPT		TSSOP14	Tape & reel	954I
TS954IYPT[1]		TSSOP14 (Automotive grade)		954Y

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.

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

5   Revision history

Table 13.   Document revision history

Date	Revision	Changes
1-May-2001	1	Initial release.
2-Jan- 2005	2	Modifications on AMR *Table 1 on page 2* (explanation of V_{id} and V_i limits, ESD MM and CDM values added, R_{thja} added).
3-Jul-2005	3	PPAP references inserted in the datasheet see *Table 12: Order codes*.
4-Aug-2005	4	Table data was badly formatted, see *Table 4 on page 5*.
15-Dec-2005	5	TS951IYLT PPAP reference added, see *Table 12: Order codes*.
10-Dec-2007	6	Added missing order codes, and automotive grade status in *Table 12: Order codes*. Updated footnotes for ESD parameters in *Table 1: Absolute maximum ratings (AMR)*. Reformatted package information.

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