TS951, TS952, TS954

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

Datasheet −production data

Features

- Rail-to-rail input common mode voltage range
- Rail-to-rail output voltage swing
- Operating from 2.7 V to 12 V
- High-speed (3 MHz, 1 V/µs)
- Low consumption (0.9 mA at 3 V)
- Supply voltage rejection ratio: 80 dB
- Latch-up immunity
- Available in SOT23-5 micropackage, DIP8, SO-8, TSSOP8, DIP14, SO-14, and TSSOP14 package

Applications

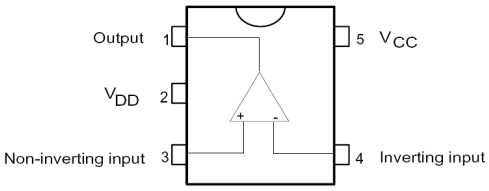
- Set-top boxes
- Laptop/notebook computers
- Transformer/line drivers
- Personal entertainment (CD players)
- Portable communications (cell phones, pagers)
- Instrumentation and sensoring
- Digital-to-analog converter buffers
- Portable headphone speaker drivers

Description

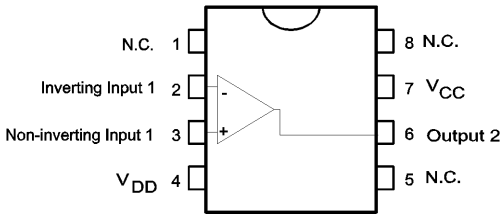
The TS951, TS952 and TS954 family of devices are rail-to-rail BiCMOS operational amplifiers optimized and fully specified for 3 V and 5 V operation.

The TS951 device 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: 2.8 mm x 2.9 mm).

TS951ILT



TS951ID



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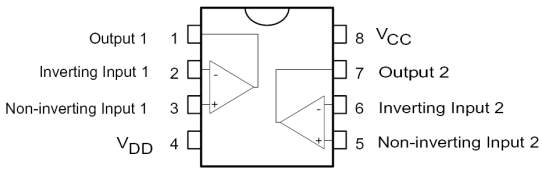

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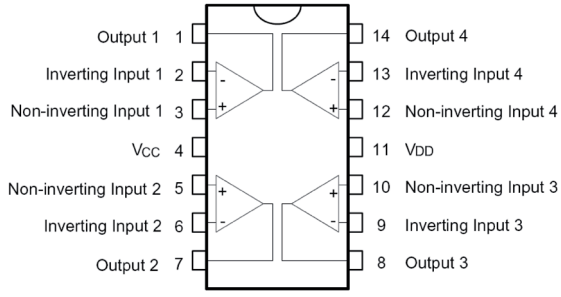


This is information on a product in full production. www.st.com

1 Absolute maximum ratings and operating conditions

Table 1. Absolute maximum ratings

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 DIP8 DIP14 TSSOP8 TSSOP14	 250 125 103 85 80 120 100	°C/W
R_{thjc}	Thermal resistance junction-to-case(4) SOT23-5 SO-8 SO-14 DIP8 DIP14 TSSOP8 TSSOP14	 81 40 31 41 33 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

Table 1. Absolute maximum ratings (continued)

Symbol	Parameter	Value	Unit
	Latch-up immunity	200	mA
	Lead temperature (soldering, 10 sec.)	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} > ±1 V, the maximum input current must not exceed ±1 mA. In this case (V_{id} > ±1 V), an input series resistor must be added to limit input current.
3. Do not exceed 14 V.
4. Short-circuits can cause excessive heating and destructive dissipation. R_{th} are typical values.
5. 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.
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 the package are charged together to the specified voltage and then discharged directly to 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. Electrical characteristics at V_{CC} = +3 V, V_{DD} = 0 V , 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 $T_{min} \le T_{amb} \le T_{max}$			6 8	mV
DV_{io}	Input offset voltage drift		2		µV/°C
I_{io}	Input offset current $T_{min} \le T_{amb} \le T_{max}$		1	30 80	nA
I_{ib}	Input bias current $V_{icm} = V_{CC}/2$ $T_{min} \le T_{amb} \le T_{max}$		35	100 200	nA
CMR	Common mode rejection ratio	50	80		dB
SVR	Supply voltage rejection ratio V_{CC} = 2.7 V to 3.3 V	60	80		dB
A_{vd}	Large signal voltage gain V_o = 2 V_{pk-pk}, R_L = 600 Ω		80		dB
V_{OH}	High level output voltage R_L = 600 Ω	2.8	2.9		V
V_{OL}	Low level output voltage R_L = 600 Ω		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 = 2 k Ω		3		MHz
SR	Slew rate		1		V/µs
∅m	Phase margin at unit gain R_L = 600 Ω, C_L =100 pF		60		Degrees
Gm	Gain margin R_L = 600 Ω, C_L =100 pF		10		dB
e_n	Equivalent input noise voltage f = 1 kHz		25		$\frac{nV}{\sqrt{Hz}}$
THD	Total harmonic distortion V_{out} = 4 V_{pk-pk}, F = 10 kHz, A_V = 2, R_L =10 kΩ		0.01		%

Table 4. Electrical characteristics at V_{CC} = +5 V, V_{DD} = 0 V, 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 $T_{min} \le T_{amb} \le T_{max}$			6 8	mV
DV_{io}	Input offset voltage drift		2		µV/°C
I_{io}	Input offset current $V_{icm} = V_{CC}/2$ $T_{min} \le T_{amb} \le T_{max}$		1	30 80	nA
I_{ib}	Input bias current $V_{icm} = V_{CC}/2$ $T_{min} \le T_{amb} \le T_{max}$		35	100 200	nA
CMR	Common mode rejection ratio	50	80		dB
SVR	Supply voltage rejection ratio V_{CC} = 2.7 V to 3.3 V	60	80		dB
A_{vd}	Large signal voltage gain V_o = 2 V_{pk-pk}, R_L = 600 Ω		86		dB
V_{OH}	High level output voltage R_L = 600 Ω	4.7	4.8		V
V_{OL}	Low level output voltage R_L = 600 Ω		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 = 2 kΩ		3		MHz
SR	Slew rate		1		V/µs
∅m	Phase margin at unit gain R_L = 600 Ω, C_L =100 pF		60		Degrees
Gm	Gain margin R_L = 600 Ω, C_L =100 pF		10		dB
e_n	Equivalent input noise voltage f = 1 kHz		25		$\frac{nV}{\sqrt{Hz}}$
THD	Total harmonic distortion V_{out} = 4 V_{pk-pk}, F = 10 kHz, A_V = 2, R_L =10 kΩ		0.01		%

Figure 1. Supply current vs. supply voltage

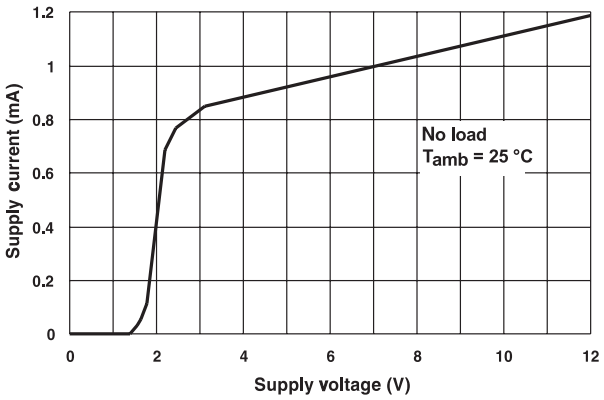


Figure 2. Output short-circuit current vs. output voltage

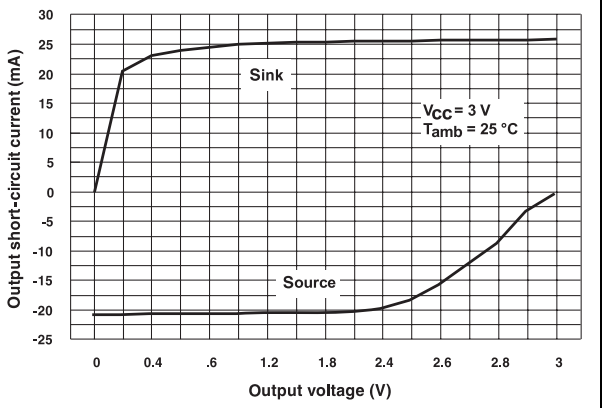


Figure 3. Voltage gain and phase vs. frequency

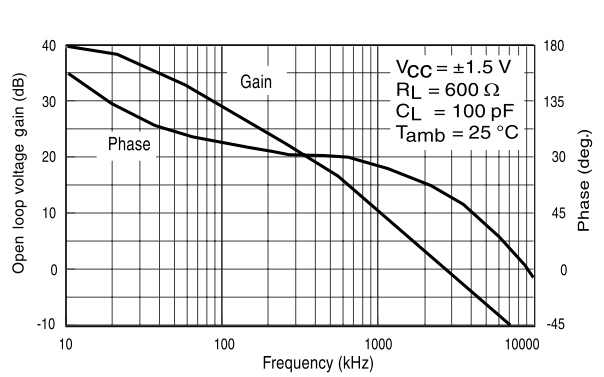


Figure 4. Supply current vs. temperature

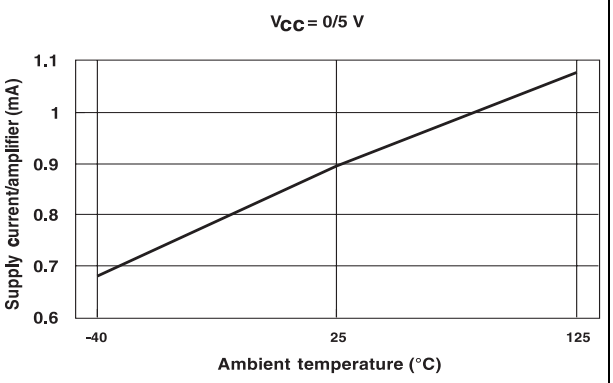


Figure 5. Output short-circuit current vs. temperature

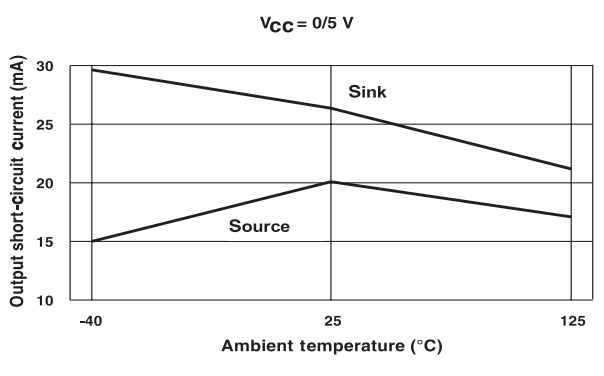


Figure 6. Slew rate vs. temperature

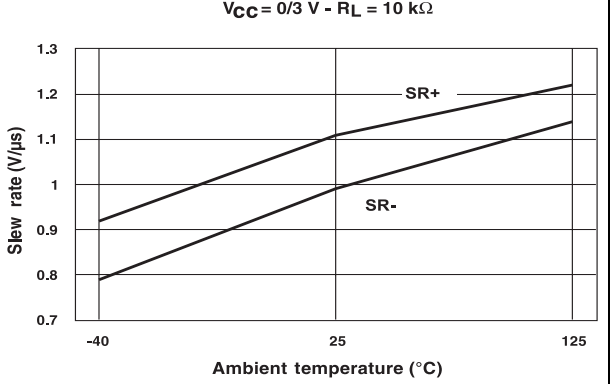


Figure 7. THD + noise vs. V_{out} (V_{CC} = ± 1.5 V, R_L = 600 Ω, f = 1 kHz, G = -1)

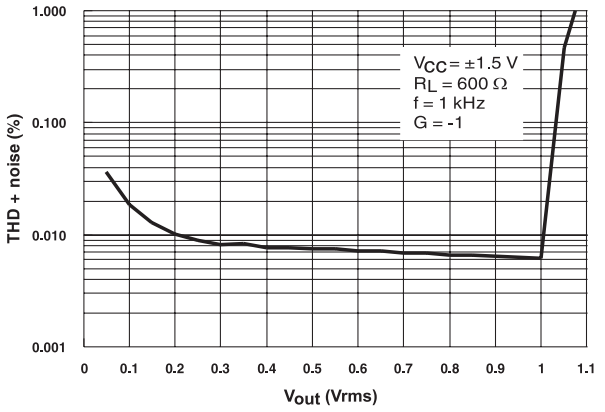


Figure 8. THD + noise vs. frequency

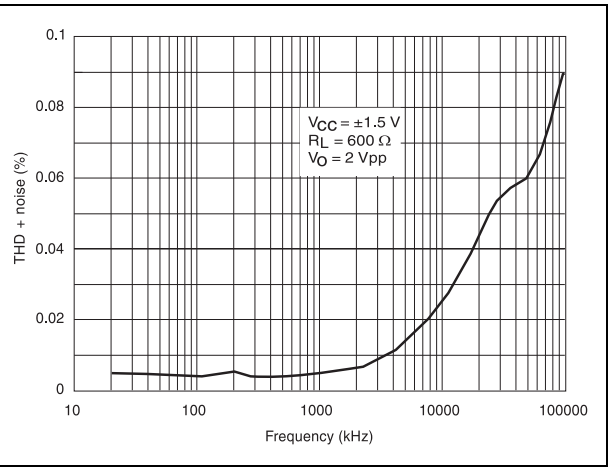


Figure 9. THD + noise vs. V_{out} (V_{CC} = ± 1.5 V, R_L = 2 kΩ, f = 1 kHz, G = -1)

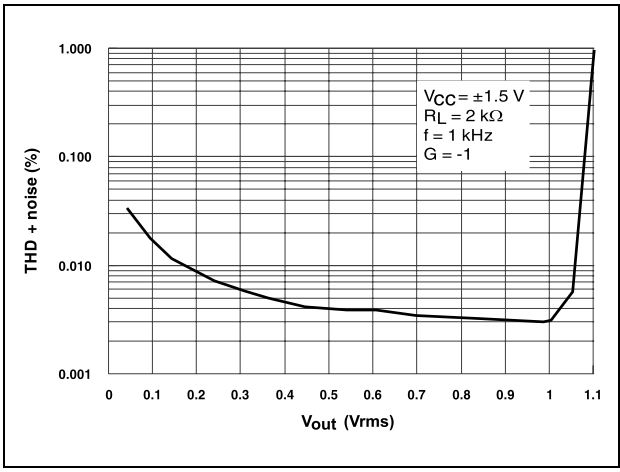
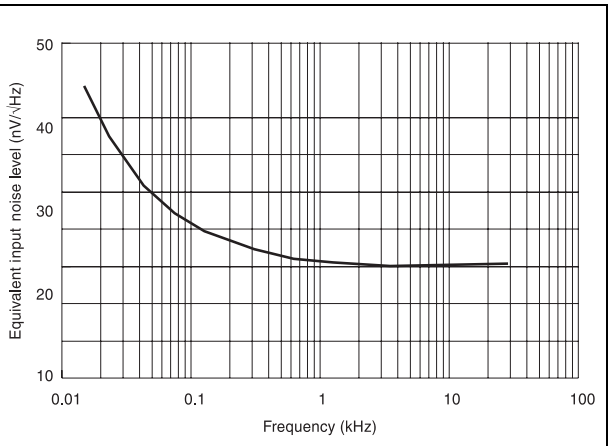


Figure 10. Equivalent input noise voltage vs. frequency



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 11. SOT23-5 package outline

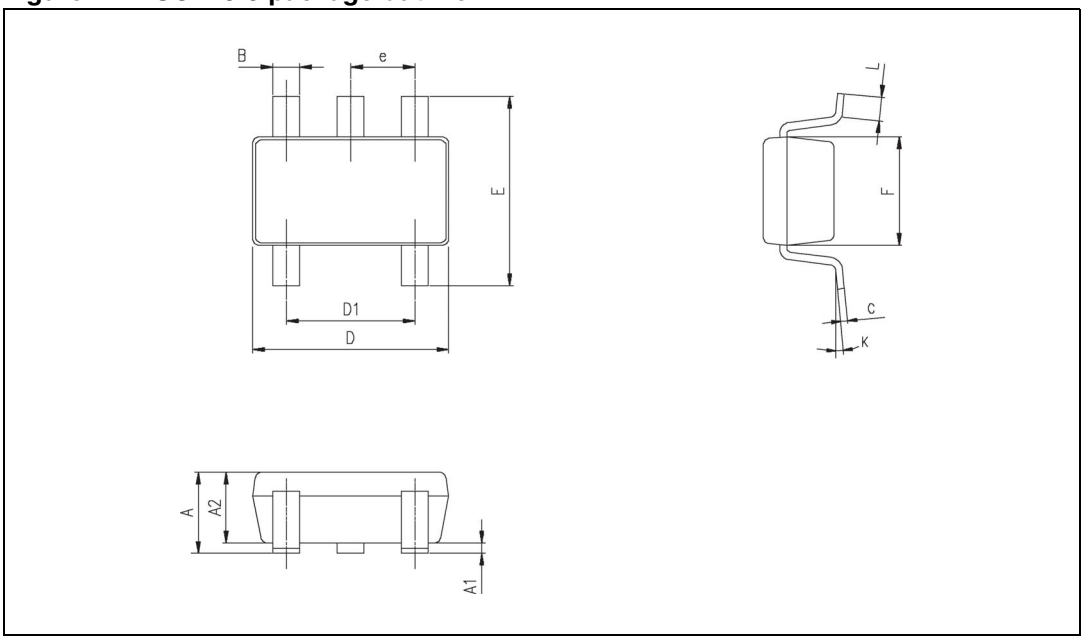


Table 5. SOT23-5 package mechanical data

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 degrees		10 degrees			

3.2 DIP8 package information

Figure 12. DIP8 package outline

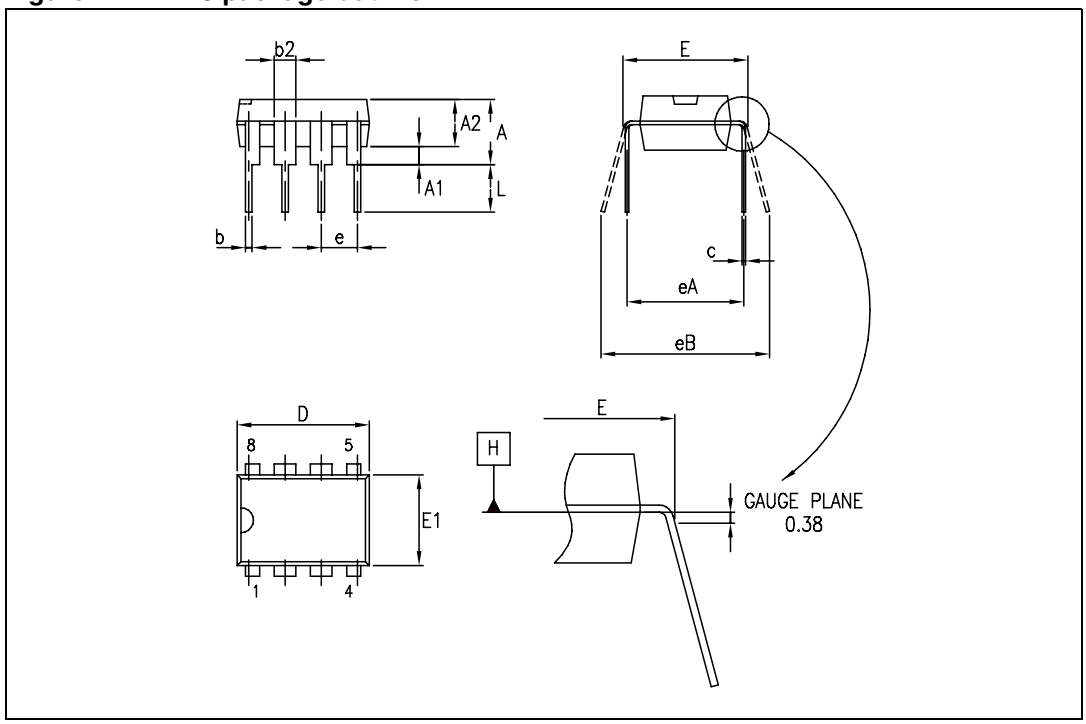


Table 6. DIP8 package mechanical data

Symbol	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 outline

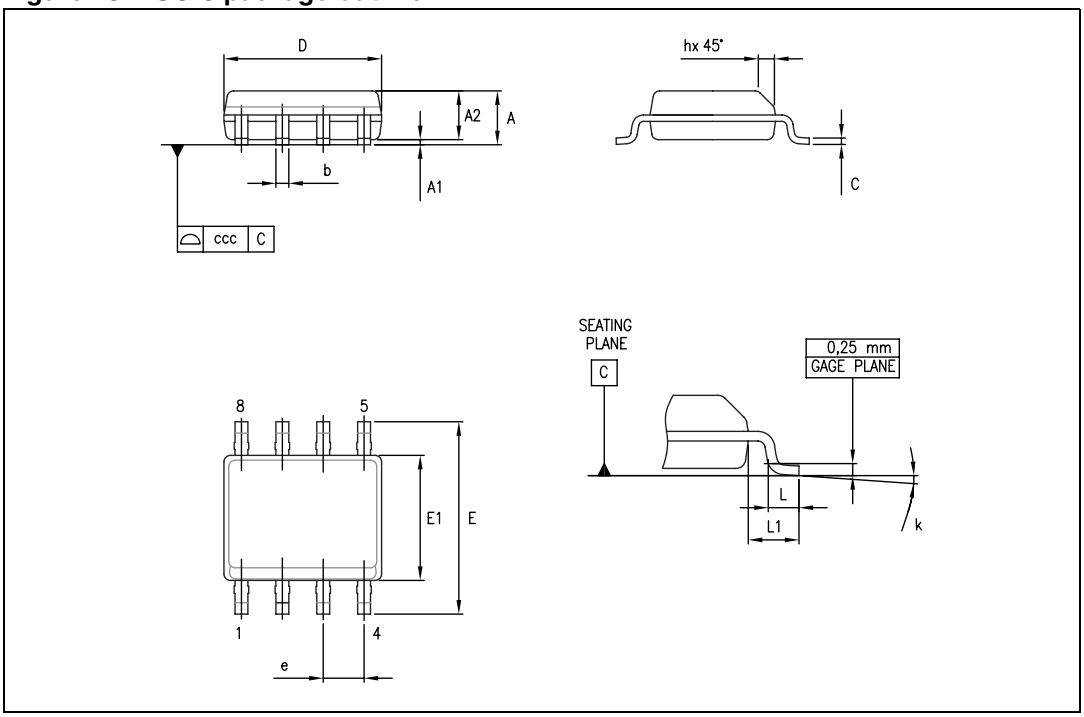


Table 7. SO-8 package mechanical data

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	1°		8°	1°		8°
ccc			0.10			0.004

3.4 TSSOP8 package information

Figure 14. TSSOP8 package outline

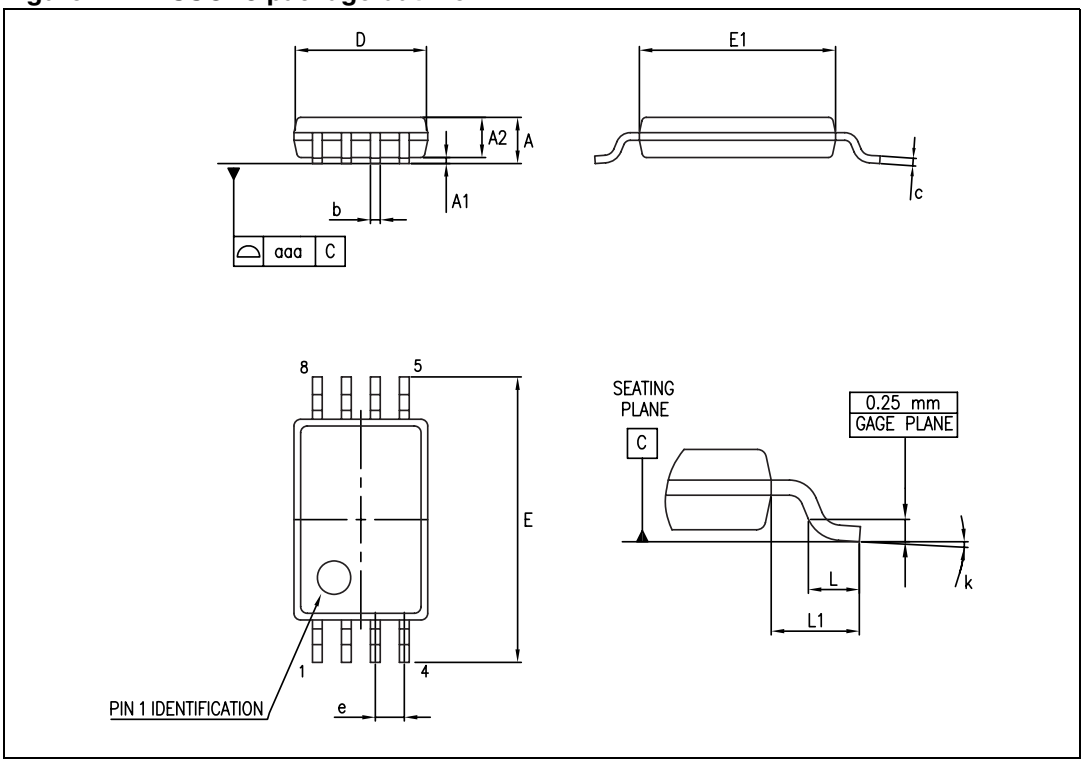


Table 8. TSSOP8 package mechanical data

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			0.039	
aaa			0.10			0.004

3.5 DIP14 package information

Figure 15. DIP14 package outline

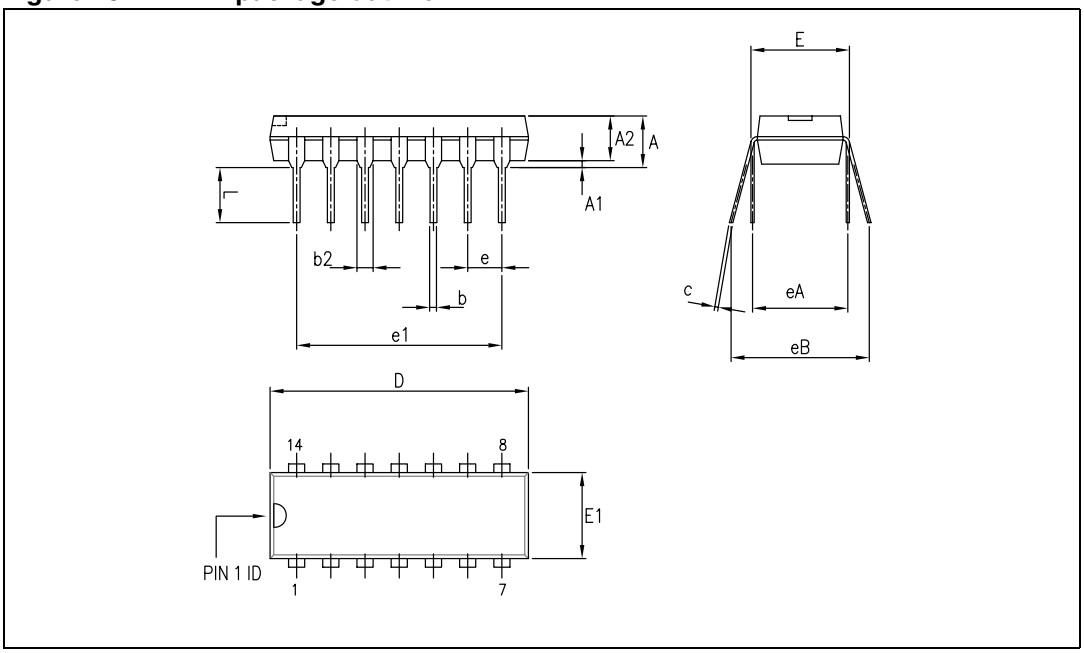


Table 9. DIP14 package mechanical data

Symbol	Dimensions					
	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			5.33			0.21
A1	0.38			0.015		
A2	2.92	3.30	4.95	0.11	0.13	0.19
b	0.36	0.46	0.56	0.014	0.018	0.022
b2	1.14	1.52	1.78	0.04	0.06	0.07
c	0.20	0.25	0.36	0.007	0.009	0.01
D	18.67	19.05	19.69	0.73	0.75	0.77
E	7.62	7.87	8.26	0.30	0.31	0.32
E1	6.10	6.35	7.11	0.24	0.25	0.28
e		2.54			0.10	
e1		15.24			0.60	
eA		7.62			0.30	
eB			10.92			0.43
L	2.92	3.30	3.81	0.11	0.13	0.15

3.6 SO-14 package information

Figure 16. SO-14 package outline

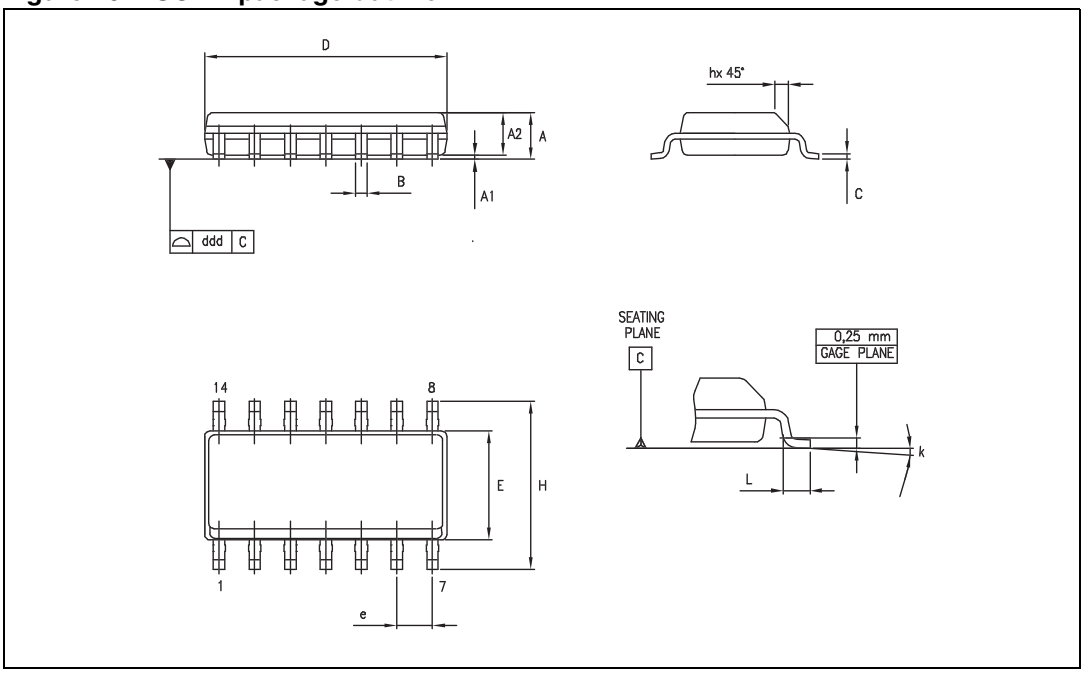


Table 10. SO-14 package mechanical data

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

3.7 TSSOP14 package information

Figure 17. TSSOP14 package outline

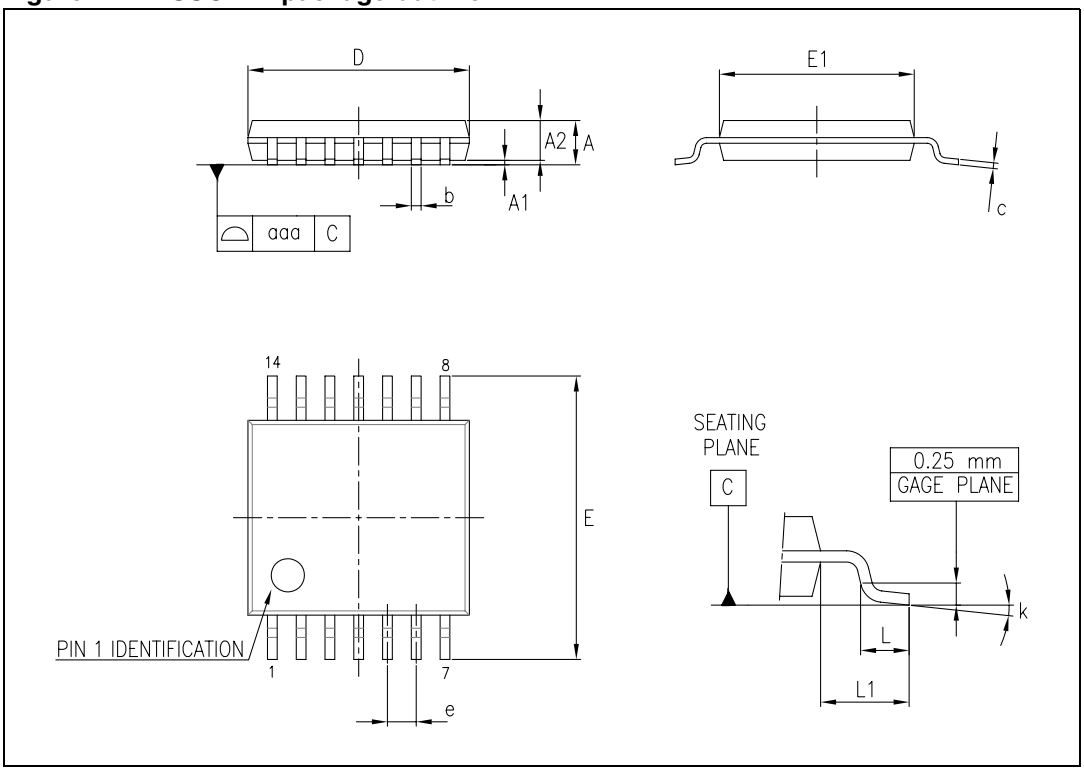


Table 11. TSSOP14 package mechanical data

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 12. Order codes

Order code	Temperature range	Package	Packaging	Marking
TS951ID TS951IDT	-40 °C to +125 °C	SO-8	Tube or tape and reel	951I
TS951ILT		SOT23-5L	Tape and reel	K101
TS951IYLT(1)		SOT23-5L (automotive grade)		K1A2
TS952IN		DIP8	Tube	TS952IN
TS952ID TS952IDT		SO-8	Tube or tape and reel	952I
TS952IYDT(1)		SO-8 (automotive grade)		952IY
TS952IPT		TSSOP8	Tape and reel	952I
TS952IYPT(1)		TSSOP8 (automotive grade)		952Y
TS954IN		DIP14	Tube	TS954IN
TS954ID TS954IDT		SO-14	Tube or tape and reel	954I
TS954IYDT(1)		SO-14 (automotive grade)		954IY
TS954IPT		TSSOP14	Tape and reel	954I
TS954IYPT(1)		TSSOP14 (automotive grade)		954Y

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 13. Document revision history

Date	Revision	Changes
01-May-2001	1	Initial release.
02-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).
03-Jul-2005	3	PPAP references inserted in the datasheet see *Table 12: Order codes*.
04-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*. Reformatted package information.
10-Mar-2009	7	Removed TS951IN and TS951IYD/DT from *Table 12: Order codes*.
24-Feb-2011	8	Changed TS951IYLT marking and updated automotive grade status in *Table 12: Order codes*.
21-Nov-2012	9	Updated *Features* (added DIP8, SO-8, TSSOP8, DIP14, SO-14, and TSSOP14 package). Updated *Table 1* (added values of DIP8 and DIP14 packages for R_{thja} and R_{thjc} symbols). Updated title of *Figure 7* and *Figure 9* (added conditions). Updated *Table 12* (removed TS952IYD and TS954IYD order code, qualified status of TS954IYPT and TS952IYPT order code). Minor corrections throughout document.

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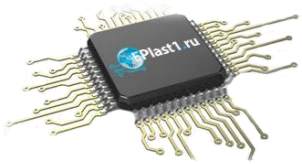

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