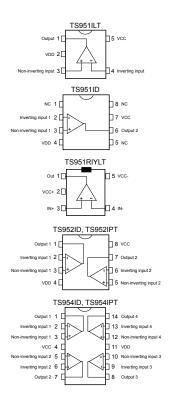


Input/output rail-to-rail low-power operational amplifiers



Product status link

TS951, TS952, TS954

Features

- · Rail-to-rail input common mode voltage range
- · Rail-to-rail output voltage swing
- Operates 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, SO8, TSSOP8, SO14, and TSSOP14 packages

Applications

- · Industrial and automotive signal conditioning
- · Active filtering
- · Medical instrumentation
- 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).



1 Absolute maximum ratings and operating conditions

Table 1. Absolute maximum ratings

Symbol	Parameter		Value	Unit
V _{CC}	Supply voltage (1)		14	
V _{id}	Differential input voltage (2)		±1	V
V _{in}	Input voltage (3)		V _{DD} - 0.3 to V _{CC} + 0.3	
T _{stg}	Storage temperature range		-65 to 150	
Tj	Maximum junction temperature		150	°C
		SOT23-5	250	
		SO8	125	
R _{thja}	Thermal resistance junction-to-ambient (4)	TSSOP8	120	
		SO14	103	
		TSSOP14	100	°C/W
		SOT23-5	81	- C/VV
	Thermal resistance junction-to-case (4)	SO8	40	
R_{thjc}		TSSOP8	37	
		SO14	31	
		TSSOP14	32	
		TS951	1	
	HBM: human body model (5)	TS952	2	kV
	TS95		3	
ESD	MM: machine model (6)		120	V
		TS951	1.5	
	CDM: charged device model (7)	TS952	1.5	kV
	TS954		1	
	Latch-up immunity		200	mA
	Lead temperature (soldering, 10 s)		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 $V_{id} > \pm 1 \ V$, 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. Do not exceed 14 V.
- 4. Short-circuits can cause excessive heating and destructive dissipation. R_{th} are typical values.
- 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.
- 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.

DS1256 - Rev 13 page 2/15



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

DS1256 - Rev 13 page 3/15



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			Тур.	Max.	Unit
V	Input offset voltage				6	m)/
V_{io}	$T_{min} \le T_{amb} \le T_{max}$				8	mV
$\Delta V_{io}/\Delta T$	Input offset voltage drift			2		μV/°C
1	land official accuracy			1	30	
l _{io}	Input offset current	$T_{min} \le T_{amb} \le T_{max}$			80	
	land him and h	V _{icm} = V _{CC} /2		35	100	nA
l _{ib}	Input bias current	$T_{min} \le T_{amb} \le T_{max}$			200	
CMR	Common mode rejection ratio		50	80		
SVR	Supply voltage rejection ratio, V _{CC} = 2.7 V to 3.3 V		60	80		dB
A _{vd}	Large signal voltage gain, $V_0 = 2 V_{pk-pk}$, $R_L = 600 \Omega$			80		
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			
I _{CC}	Supply current (per amplifier), no load, $V_{icm} = V_{CC}/2$			0.9	1.3	– mA
GBP	Gain bandwidth product, $R_L = 2 \text{ k}\Omega$			3		MHz
SR	Slew rate			1		V/µs
Øm	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		nV / √Hz
THD	Total harmonic distortion, $V_{out} = 4 V_{pk-pk}$, $F = 10 kHz$, $A_V = 2$, $R_L = 10 k\Omega$			0.01		%

DS1256 - Rev 13 page 4/15



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			Тур.	Max.	Unit
\/.	Input offset voltage				6	mV
V_{io}	$T_{min} \le T_{amb} \le T_{max}$				8	mv
$\Delta V_{io}/\Delta T$	Input offset voltage drift			2		μV/°C
ı.	Input offset surrent	V _{icm} = V _{CC} /2		1	30	
I _{io}	Input offset current	$T_{min} \le T_{amb} \le T_{max}$			80	200
I	lanut bigg gurrant	V _{icm} = V _{CC} /2		35	100	- nA
l _{ib}	Input bias current	$T_{min} \le T_{amb} \le T_{max}$			200	_
CMR	Common mode rejection ratio		50	80		
SVR	Supply voltage rejection ratio, V _{CC} = 2.7 V to 3.3 V		60	80		dB
A _{vd}	Large signal voltage gain, $V_0 = 2 V_{pk-pk}$, $R_L = 600 \Omega$			86		
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			
I _{CC}	Supply current (per amplifier), no load, V _{icm} = V _{CC} /2			0.95	1.4	- mA
GBP	Gain bandwidth product, $R_L = 2 k\Omega$			3		MHz
SR	Slew rate			1		V/µs
Øm	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		nV / √Hz
THD	Total harmonic distortion, V_{out} = 4 V_{pk-pk} , F = 10 kHz, A_V = 2, R_L = 10 k Ω			0.01		%

DS1256 - Rev 13 page 5/15





Electrical characteristic curves

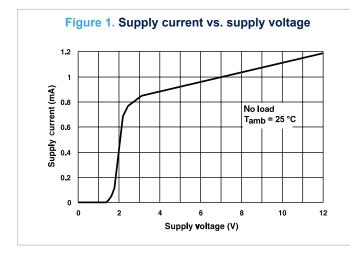
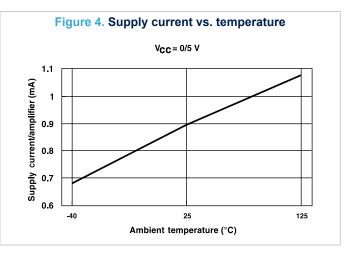
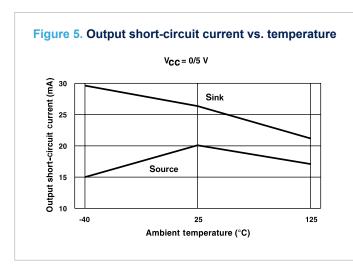
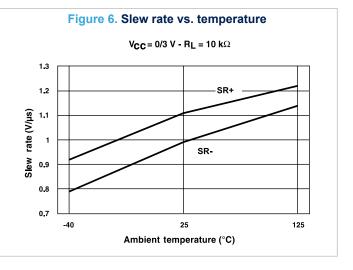


Figure 2. Output short-circuit current vs. output voltage 25 Output short-circuit current (mA) Sink 20 15 V_{CC} = 3 V T_{amb} = 25 °C 10 5 -10 -15 Source -20 0 0.4 1.8 2.4 1.2 Output voltage (V)

Figure 3. Voltage gain and phase vs. frequency $V_{CC} = \pm 1.5 \text{ V}$ $R_{L} = 600 \Omega$ $C_{L} = 100 \text{ pF}$ Gain Open loop voltage gain (dB) 30 T_{amb} = 25 °C S 85 Phase (deg.) 10 -45 1000 Frequency (kHz) 10000







DS1256 - Rev 13 page 6/15

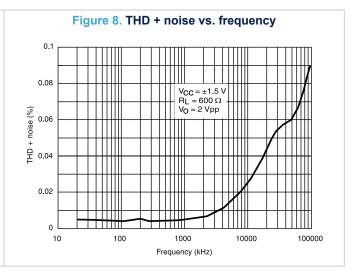


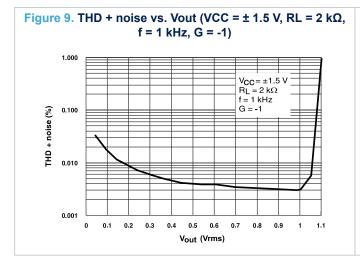
Figure 7. THD + noise vs. Vout (VCC = \pm 1.5 V, RL = 600 Ω , f = 1 kHz, G = -1)

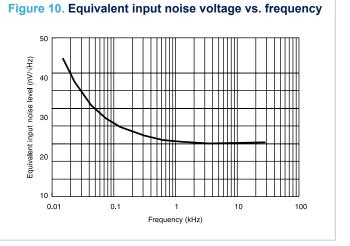
1.000 $V_{CC} = \pm 1.5 \text{ V}$ $R_{L} = 600 \Omega$ G = -1 G = -1 G = -1 G = -1

Vout (Vrms)

 $0.1 \quad \ \ 0.2 \quad \ \ 0.3 \quad \ \ 0.4 \quad \ \ 0.5 \quad \ \ 0.6 \quad \ \ 0.7 \quad \ \ 0.8 \quad \ \ 0.9$







DS1256 - Rev 13 page 7/15



4 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.

4.1 SOT23-5 package information

Figure 11. SOT23-5 package outline

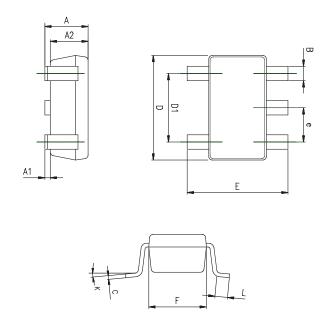


Table 5. SOT23-5 mechanical data

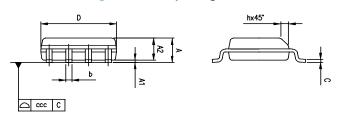
	Dimensions							
Ref.		Millimeters		Inches				
	Min.	Тур.	Max.	Min.	Тур.	Max.		
А	0.90	1.20	1.45	0.035	0.047	0.057		
A1			0.15			0.006		
A2	0.90	1.05	1.30	0.035	0.041	0.051		
В	0.35	0.40	0.50	0.014	0.016	0.020		
С	0.09	0.15	0.20	0.004	0.006	0.008		
D	2.80	2.90	3.00	0.110	0.114	0.118		
D1		1.90			0.075			
е		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	0.014	0.024		
K	0 degrees		10 degrees	0 degrees		10 degrees		

DS1256 - Rev 13 page 8/15



4.2 SO8 package information

Figure 12. SO8 package outline



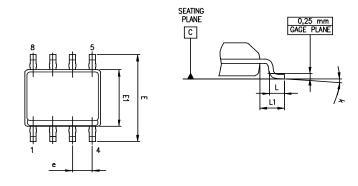


Table 6. SO8 package mechanical data

	Dimensions							
Ref.		Millimeters		Inches				
	Min.	Тур.	Max.	Min.	Тур.	Max.		
А			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		
С	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		
е		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°	0°		8°		
ccc			0.10			0.004		

DS1256 - Rev 13 page 9/15



4.3 TSSOP8 package information

Figure 13. TSSOP8 package outline

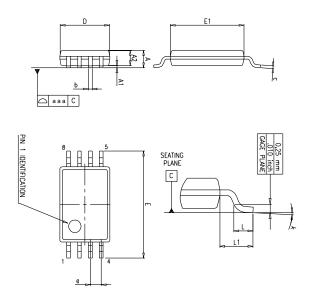


Table 7. TSSOP8 package mechanical data

	Dimensions							
Ref.		Millimeters		Inches				
	Min.	Тур.	Max.	Min.	Тур.	Max.		
Α			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		
С	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		
е		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		

DS1256 - Rev 13 page 10/15



4.4 SO14 package information

Figure 14. SO14 package outline

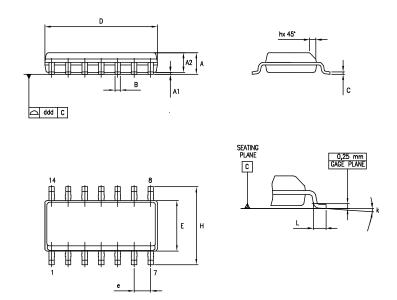


Table 8. SO14 package mechanical data

	Dimensions							
Ref.		Millimeters		Inches				
	Min.	Тур.	Max.	Min.	Тур.	Max.		
			1.75			0.069		
А	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		
В	0.33		0.51	0.01		0.02		
С	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		
е		1.27			0.05			
Н	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		

DS1256 - Rev 13 page 11/15



4.5 TSSOP14 package information

Figure 15. TSSOP14 package outline

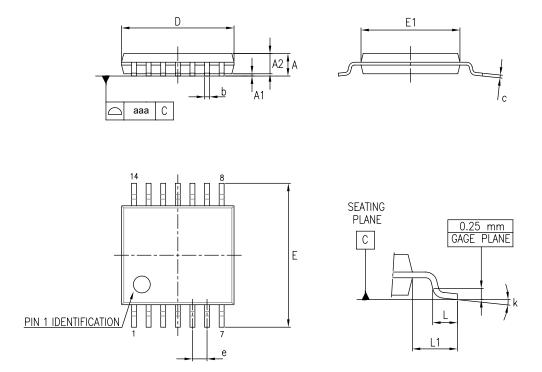


Table 9. TSSOP14 package mechanical data

	Dimensions							
Ref.		Millimeters		Inches				
	Min.	Тур.	Max.	Min.	Тур.	Max.		
А			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		
С	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		
е		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		

DS1256 - Rev 13 page 12/15





5 Ordering information

Table 10. Order codes

Order code	Temperature range	Package	Packaging	Marking
TS951IDT		SO8		9511
TS951ILT		SOT23-5		K101
TS951IYLT (1)		SOT23-5		K102
TS951RIYLT		(automotive grade)		K103
TS952IDT		SO8		9521
TS952IYDT ⁽¹⁾		SO8		952IY
13932110107		(automotive grade)	Tape and reel	93211
TS952IPT	-40 °C to 125 °C	TSSOP8		9521
TS952IYPT ⁽¹⁾		TSSOP8	Tapo ana Too.	952Y
10992111 117		(automotive grade)		3321
TS954IDT		SO14		9541
TS954IYDT ⁽¹⁾		SO14		954IY
10904110117		(automotive grade)		33411
TS954IPT		TSSOP14		9541
TS954IYPT ⁽¹⁾		TSSOP14		954IY
100041111		(automotive grade)		00411

Qualified and characterized according to AEC Q100 and Q003 or equivalent, advanced screening according to AEC Q001 and Q002 or equivalent.

DS1256 - Rev 13 page 13/15



Revision history

Table 11. Document revision history

Date	Revision	Changes
01-May-2001	1	Initial release.
02-Jan-2005	2	Modifications on AMR Table 1: "Absolute maximum ratings" (explanation of Vid and Vi limits, ESD MM and CDM values added, Rthja added).
03-Jul-2005	3	PPAP references inserted in the datasheet see Table 10: "Order codes".
04-Aug-2005	4	Table data was badly formatted, see Table 4.
15-Dec-2005	5	TS951IYLT PPAP reference added, see Table 10: "Order codes".
10-Dec-2007	6	Added missing order codes, and automotive grade status in Table 10: "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 10: "Order codes".
24-Feb-2011	8	Changed TS951IYLT marking and updated automotive grade status in in Table 10: "Order codes".
21-Nov-2012	9	Updated Features (added DIP8, SO-8, TSSOP8, DIP14, SO-14, and TSSOP14 packages). Updated Table 1: "Absolute maximum ratings" (added values of DIP8 and DIP14 packages for R _{thja} and R _{thjc} symbols). Updated title of Figure 7 and Figure 9 (added conditions). <i>Note that these figures were subsequently removed in revision 10 below</i> . Updated Table 10: "Order codes" (removed TS952IYD and TS954IYD order codes, qualified status of TS954IYPT and TS952IYPT order codes). Minor corrections throughout document.
11-Sep-2013	10	Removed DIP8 and DIP14 packages and all information pertaining to them. Table 10: "Order codes"; updated marking of order code TS951IYLT from K1A2 to K102.
27-Jun-2014	11	Updated ESD(MM) in Table 1: "Absolute maximum ratings" Updated Table 10: "Order codes"
13-Mar-2015	12	Added order code TS951RIYLT throughout document
16-Oct-2019	13	Updated applications in cover page and Table 10. Order codes.



IMPORTANT NOTICE - PLEASE READ CAREFULLY

STMicroelectronics NV and its subsidiaries ("ST") reserve the right to make changes, corrections, enhancements, modifications, and improvements to ST products and/or to this document at any time without notice. Purchasers should obtain the latest relevant information on ST products before placing orders. ST products are sold pursuant to ST's terms and conditions of sale in place at the time of order acknowledgement.

Purchasers are solely responsible for the choice, selection, and use of ST products and ST assumes no liability for application assistance or the design of Purchasers' products.

No license, express or implied, to any intellectual property right is granted by ST herein.

Resale of ST products with provisions different from the information set forth herein shall void any warranty granted by ST for such product.

ST and the ST logo are trademarks of ST. For additional information about ST trademarks, please refer to www.st.com/trademarks. All other product or service names are the property of their respective owners.

Information in this document supersedes and replaces information previously supplied in any prior versions of this document.

© 2019 STMicroelectronics - All rights reserved

DS1256 - Rev 13 page 15/15