1   Absolute maximum ratings and operating conditions

Table 2.   Absolute maximum ratings

Symbol	Parameter	Value	Unit
V_{CC}	Supply voltage[1]	12	V
V_{id}	Differential input voltage[2]	$\pm V_{CC}$	V
V_{in}	Input voltage range[3]	V_{CC-} -0.3 to V_{CC+} +0.3	V
I_{in}	Input current range[4]	10	mA
T_{std}	Storage temperature range	-65 to +150	°C
T_j	Maximum junction temperature	150	°C
R_{thja}	Thermal resistance junction-to-ambient[5] – SOT23-5 – SO8 – SO14 – TSSOP14	250 125 103 100	°C/W
ESD	HBM: human body model[6]	2	kV
	MM: machine model[7]	200	V
	CDM: charged device model[8]	2	kV
	Latch-up immunity	200	mA
	Soldering temperature (10 sec.), leaded version	250	°C

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

2. Differential voltages are 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. Input current must be limited by a resistor in series with the inputs.

5. Short-circuits can cause excessive heating and destructive dissipation.

6. Human body model: 100 pF discharged through a 1.5 kΩ resistor into pin of device.

7. Machine model ESD: a 200 pF capacitor is charged to the specified voltage, then discharged directly into the IC with no external series resistor (internal resistor < 5 Ω), into pin-to-pin of device.

8. 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 3.   Operating conditions

Symbol	Parameter	Value	Unit
V_{CC}	Supply voltage	2.7 to 10	V
V_{icm}	Common mode input voltage range	V_{CC-} -0.2 to V_{CC+} -1.5	V
T_{oper}	Operating free air temperature range	-40 to +105	°C

2 Electrical characteristics

Table 4 and *Table 5* give the electrical characteristics at each V_{CC} value.

Table 4.   Electrical characteristics at V_{CC}+ = +3 V, V_{CC}- = 0 V, T_{amb} = 25 °C (unless otherwise specified)

Symbol	Parameter	Min.	Typ.	Max.	Unit
V_{io}	Input offset voltage TS931/2/4 TS931/2/4A TS931/2/4B			10 5 2	mV
	$T_{min} < T_{op} < T_{max}$ TS931/2/4 TS931/2/4A TS931/2/4B			15 10 6	
ΔV_{io}	Input offset voltage drift		3		µV/°C
I_{io}	Input offset current[1] $T_{min} < T_{op} < T_{max}$		1	100 200	pA
I_{ib}	Input bias current[1] $T_{min} < T_{op} < T_{max}$		1	150 300	pA
CMR	Common mode rejection ratio, $0 \leq V_{icm} \leq V_{CC+}$ -1.7 $T_{min} < T_{op} < T_{max}$	55 55	85 85		dB
SVR	Supply voltage rejection ratio[2] $T_{min} < T_{op} < T_{max}$	55 55	85 85		dB
A_{vd}	Large signal voltage gain V_O = 2 Vpp, R_L = 1 MΩ R_L = 100 kΩ		120 106		dB
V_{OH}	High level output voltage, V_{ID} = 100 mV, R_L = 100 kΩ $T_{min} < T_{op} < T_{max}$	2.95 2.95	2.99		V
V_{OL}	Low level output voltage, V_{ID} = -100 mV, R_L = 100 kΩ $T_{min} < T_{op} < T_{max}$		10	50 50	mV
I_o	Output source current V_{ID} = 100 mV, V_O = V_{CC-} Output sink current V_{ID} = -100 mV, V_O = V_{CC+}		1.5 1.5		mA
I_{CC}	Supply current (per amplifier), A_{VCL} = 1, no load $T_{min} < T_{op} < T_{max}$		20	31 33	µA
GBP	Gain bandwidth product R_L = 100 kΩ, C_L = 50 pF		100		kHz
SR	Slew rate R_L = 100 kΩ, C_L = 50 pF		50		V/ms

Table 4.   **Electrical characteristics at $V_{CC}+$ = +3 V, $V_{CC}-$ = 0 V, T_{amb} = 25 °C (unless otherwise specified) (continued)**

Symbol	Parameter	Min.	Typ.	Max.	Unit
ϕ m	Phase margin C_L = 50 pF		65		Degrees
en	Input voltage noise		75		nV/√Hz

1. Maximum values including unavoidable inaccuracies of the industrial test.

2. V_{CC} has a 0.2 V variation.

Table 5.   **Electrical characteristics at $V_{CC}+$ = +5 V, $V_{CC}-$ = 0 V, T_{amb} = 25 °C (unless otherwise specified)**

Symbol	Parameter	Min.	Typ.	Max.	Unit

V_{io}	Input offset voltage
	  TS931/2/4
	  TS931/2/4A
	  TS931/2/4B
				10
				5
				2
					mV

	T_{min} < T_{op} < T_{max}
	  TS931/2/4
	  TS931/2/4A
	  TS931/2/4B
				15
				10
				6	

ΔV_{io}	Input offset voltage drift		3		µV/°C
I_{io}	Input offset current[1] T_{min} < T_{op} < T_{max}		1	100 200	pA
I_{ib}	Input bias current[1] T_{min} < T_{op} < T_{max}		1	150 300	pA
CMR	Common mode rejection ratio, 0 ≤ V_{icm} ≤ V_{CC+} - 1.7 T_{min} < T_{op} < T_{max}	55 55	85 85		dB
SVR	Supply voltage rejection ratio[2] T_{min} < T_{op} < T_{max}	55 55	85 85		dB

A_{vd}	Large signal voltage gain
	  V_O = 4 Vpp, R_L = 1 MΩ
	  R_L = 100 kΩ
			120
			112
					dB

V_{OH}	High level output voltage, V_{ID} = 100 mV, R_L = 100 kΩ T_{min} < T_{op} < T_{max}	4.95 4.95	4.99		V
V_{OL}	Low level output voltage, V_{ID} = -100 mV, R_L = 100 kΩ T_{min} < T_{op} < T_{max}		10	50 50	mV

I_o	Output source current
	  V_{ID} = 100 mV, V_O = V_{DD}
	Output sink current
	  V_{ID} = -100 mV, V_O = V_{CC}
			5
			
			5
					mA

I_{CC}	Supply current (per amplifier), A_{VCL} = 1, no load T_{min} < T_{op} < T_{max}		20	33 35	µA

Table 5. **Electrical characteristics at V$_{CC}$+ = +5 V, V$_{CC}$- = 0 V, T$_{amb}$ = 25 °C (unless otherwise specified) (continued)**

Symbol	Parameter	Min.	Typ.	Max.	Unit
GBP	Gain bandwidth product R$_L$ = 100 KΩ, C$_L$ = 50 pF		100		kHz
SR	Slew rate R$_L$ = 100 KΩ, C$_L$ = 50 pF		50		V/ms
φm	Phase margin C$_L$ = 50 pF		65		Degrees
en	Input voltage noise		76		nV/√Hz

1. Maximum values including unavoidable inaccuracies of the industrial test.

2. V$_{CC}$ has a 0.2 V variation.

**Figure 1.   Input offset voltage
                        vs. temperature**
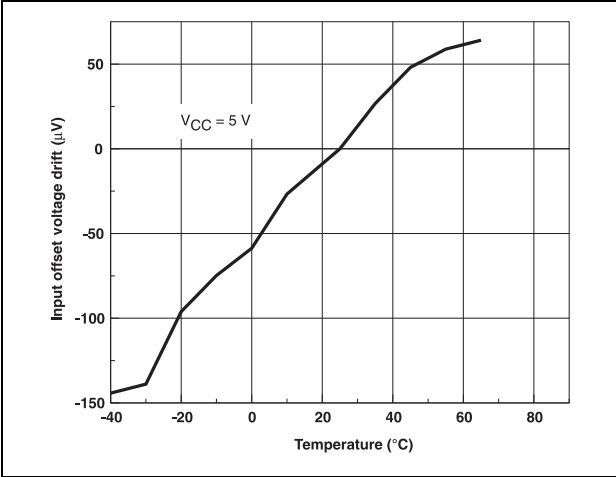
**Figure 2.   Supply current vs. supply voltage,
                        in open loop configuration**
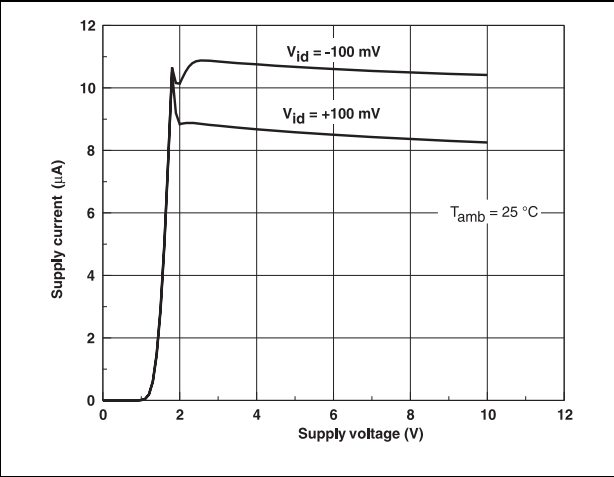
**Figure 3.   Supply current vs. supply voltage in
                        follower configuration, $V_{icm} = V_{CC}/2$**
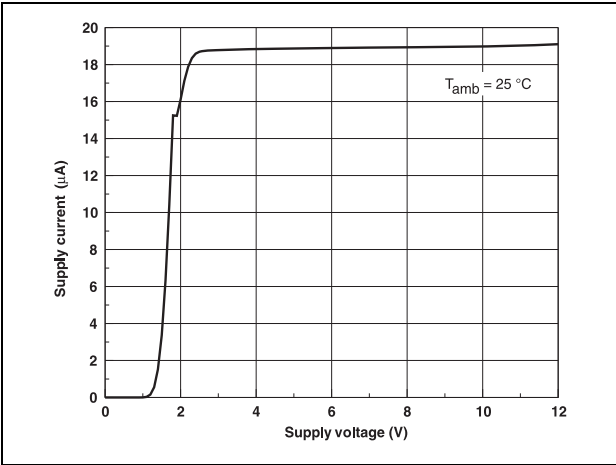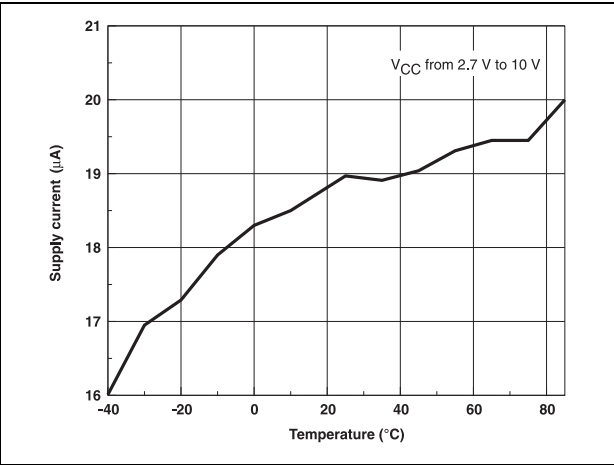

Figure 4.   Supply current vs. temperature

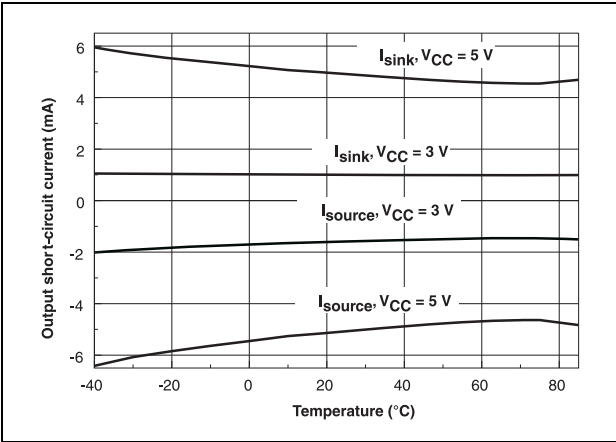**Figure 5.   Output short-circuit current
                        vs. temperature**

**Figure 6.   Output short-circuit current
                        vs. supply voltage**
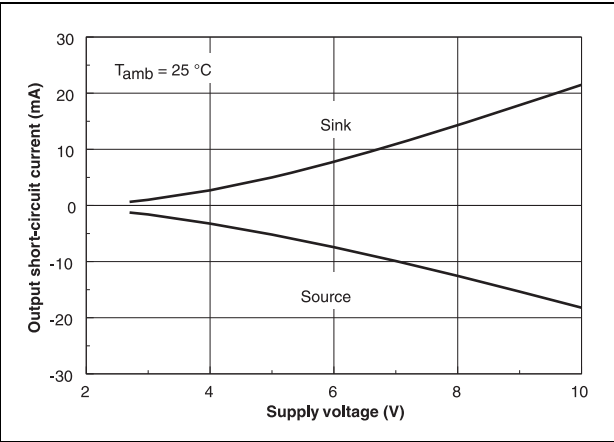
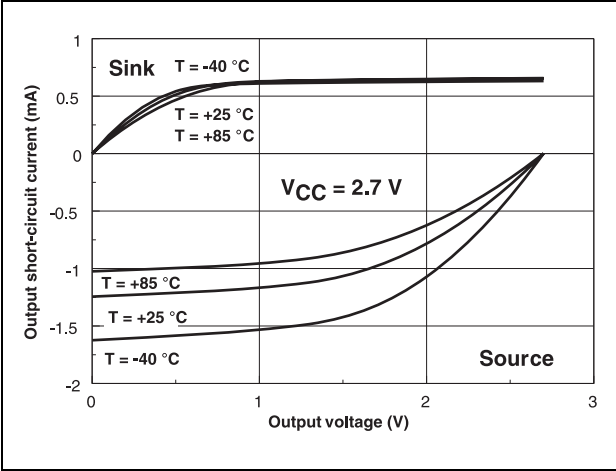**Figure 7.   Output short-circuit current vs. output voltage at V$_{CC}$+ = 2.7 V**

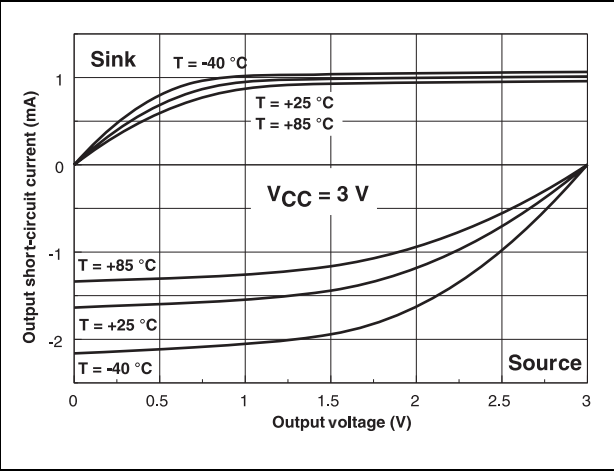**Figure 8.   Output short-circuit current vs. output voltage at V$_{CC}$+ = 3 V**

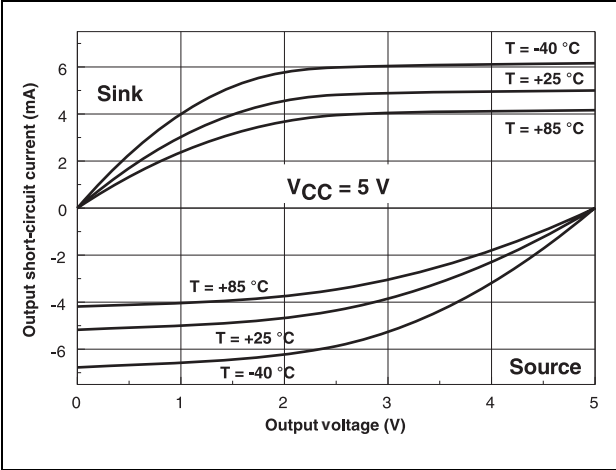**Figure 9.   Output short-circuit current vs. output voltage at V$_{CC}$+ = 5 V**

Figure 10.   Output short-circuit current vs. output voltage at V$_{CC}$+ = 10 V
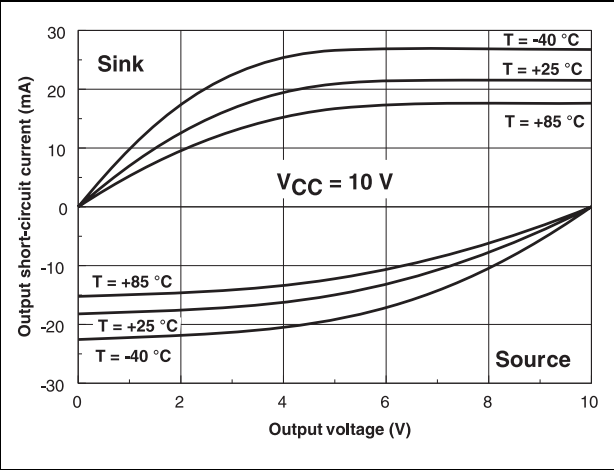

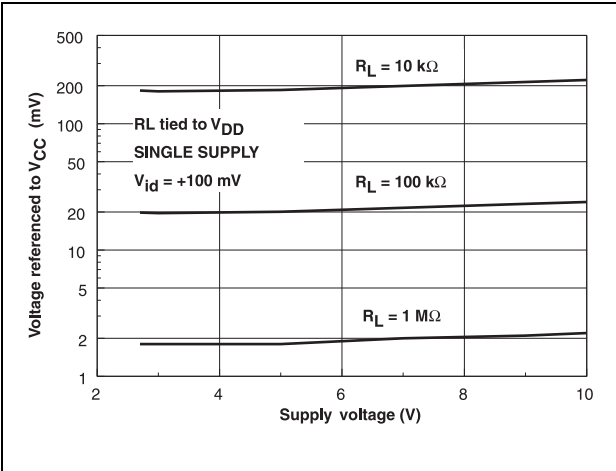**Figure 11.   High level output voltage drop vs. supply voltage**

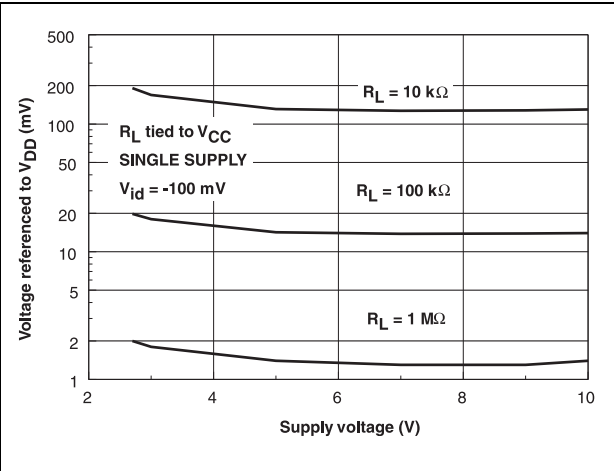**Figure 12.   Low level output voltage drop vs. supply voltage**

Figure 13. Voltage gain and phase vs. frequency for C$_L$ = 50 pF
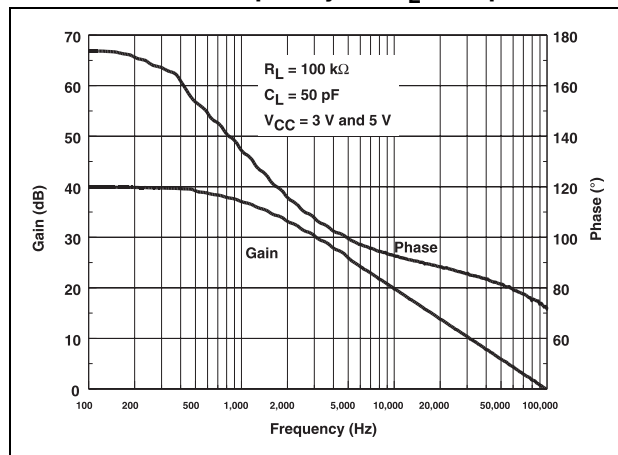
Figure 14. Voltage gain and phase vs. frequency for C$_L$ = 100 pF
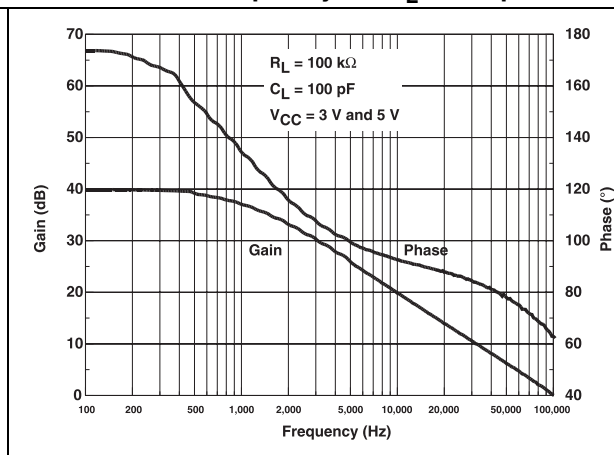
Figure 15. Distortion vs. frequency
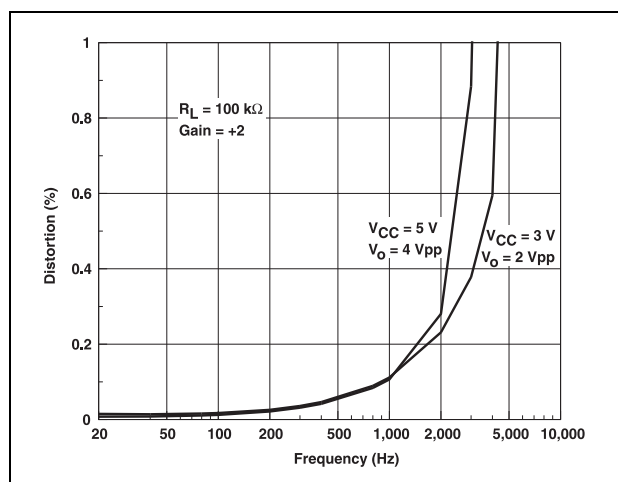
Figure 16. Equivalent input noise voltage vs. frequency
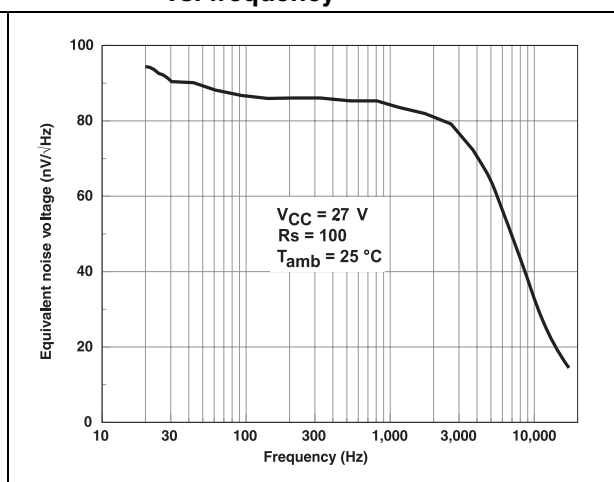
Figure 17. Distortion vs. output voltage
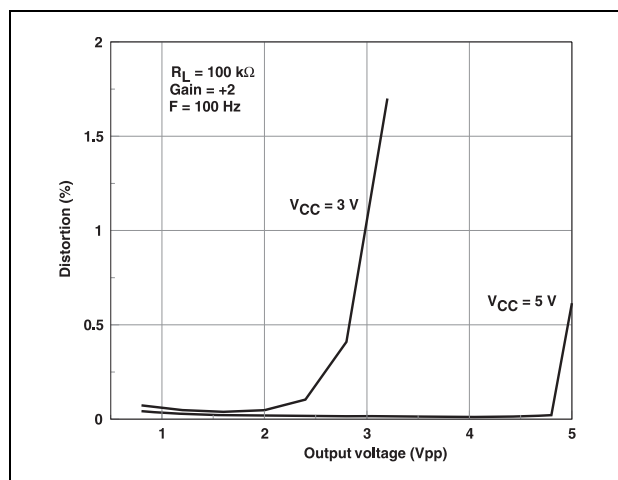
Figure 18. Supply voltage rejection vs. frequency
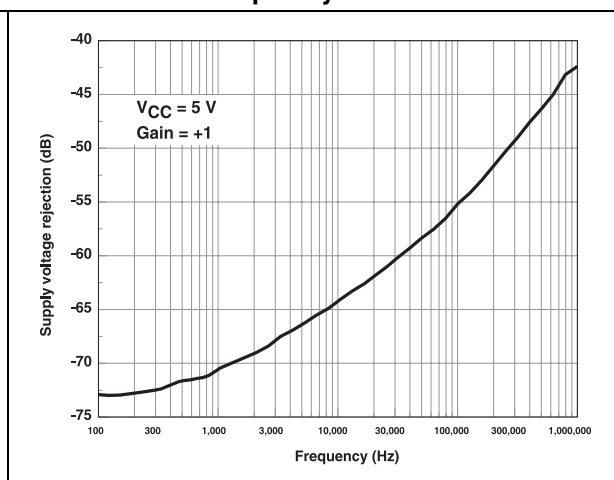
Figure 19.   Slew rate vs. time for small input voltage signal
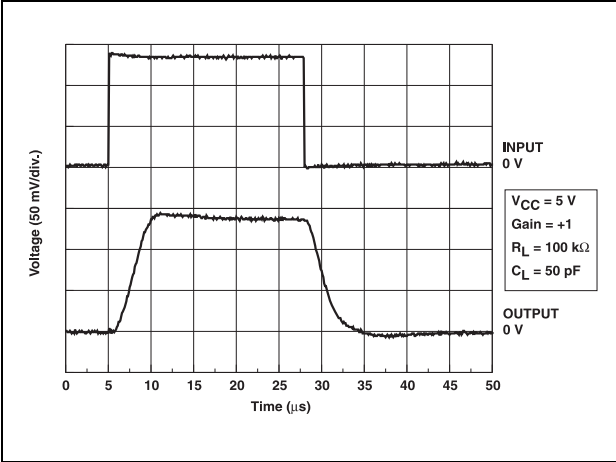
Figure 20.   Slew rate vs. time for large input voltage signal
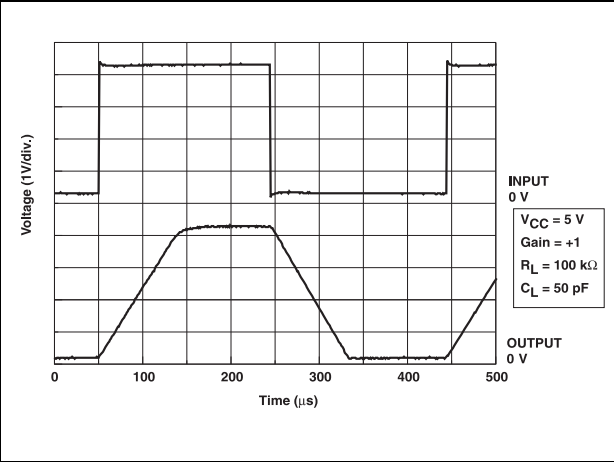
3 Package information

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 SO-8 package information

Figure 21. SO-8 package outline
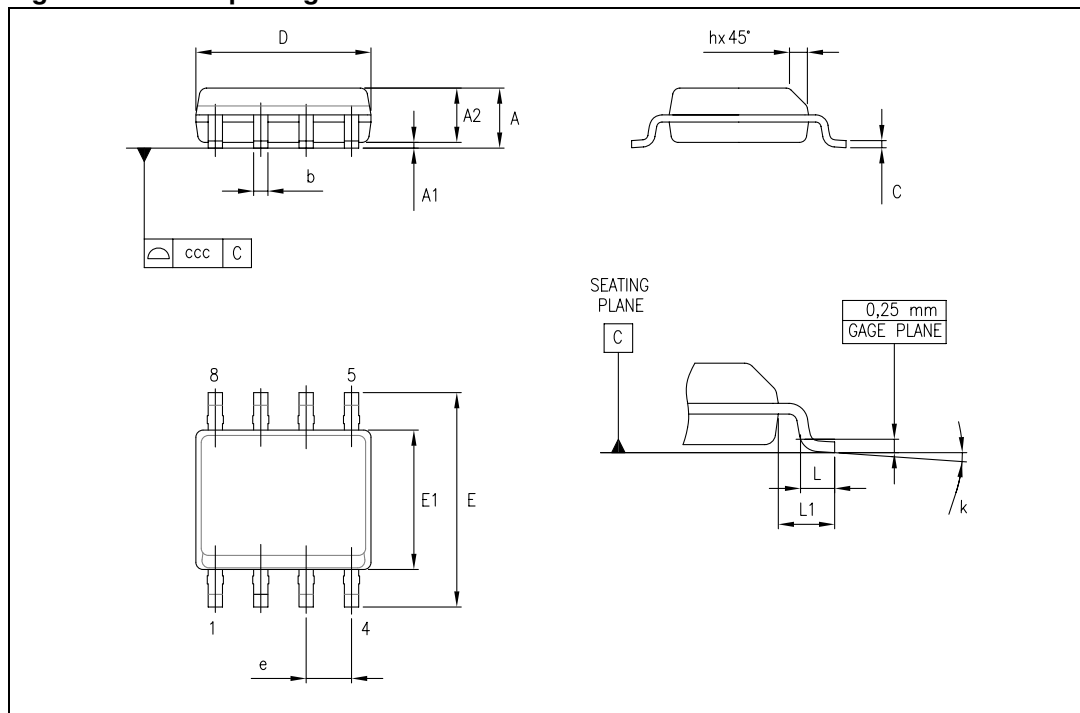
Table 6. SO-8 package mechanical data

| 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

3.2   SO-14 package information

Figure 22.   SO-14 package outline
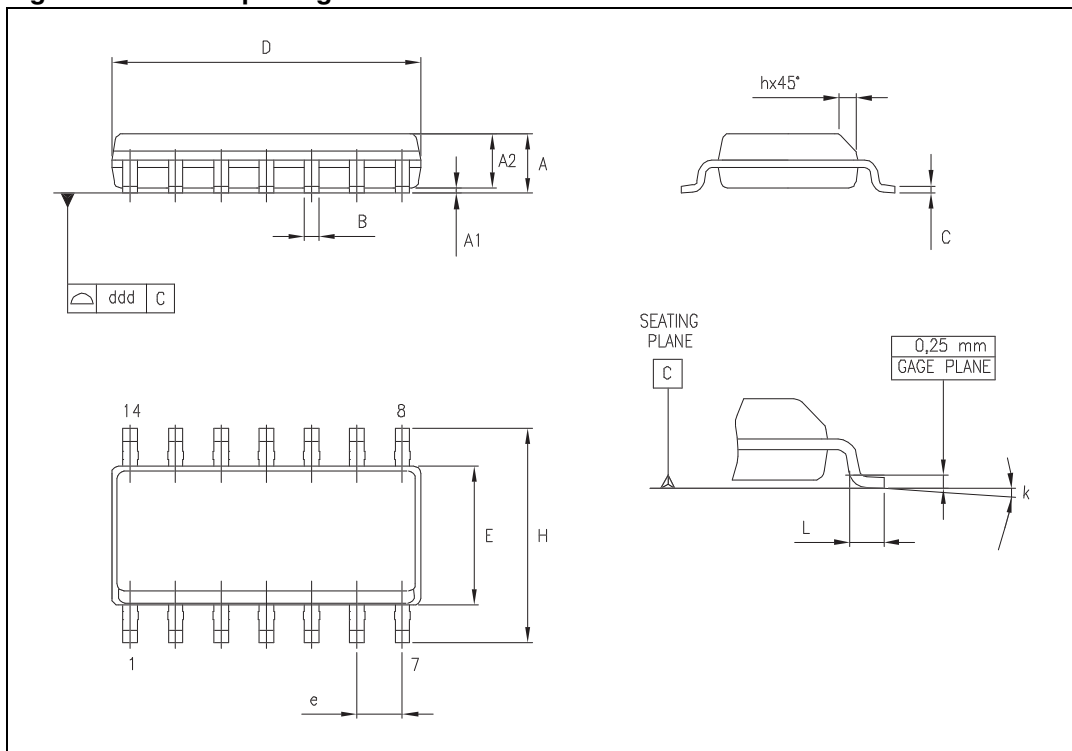
Table 7.   SO-14 package mechanical data

Symbol	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

3.3 TSSOP14 package information

Figure 23. TSSOP14 package outline
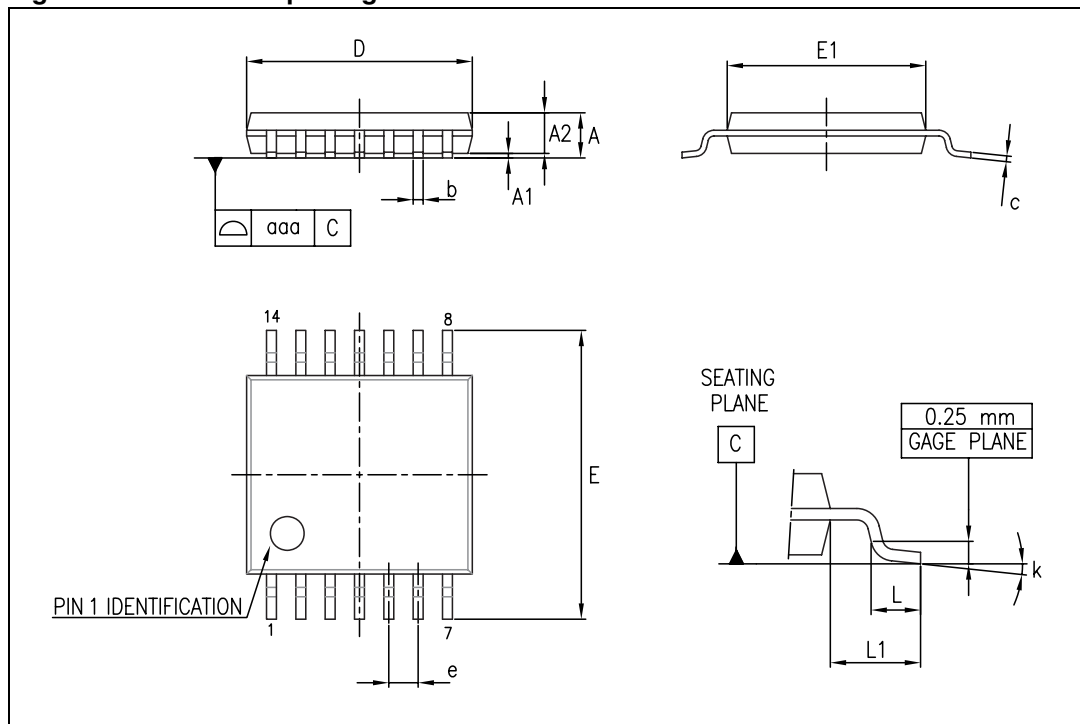
Table 8. TSSOP14 package mechanical data

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

3.4   SOT23-5 package information

Figure 24.   SOT23-5 package outline
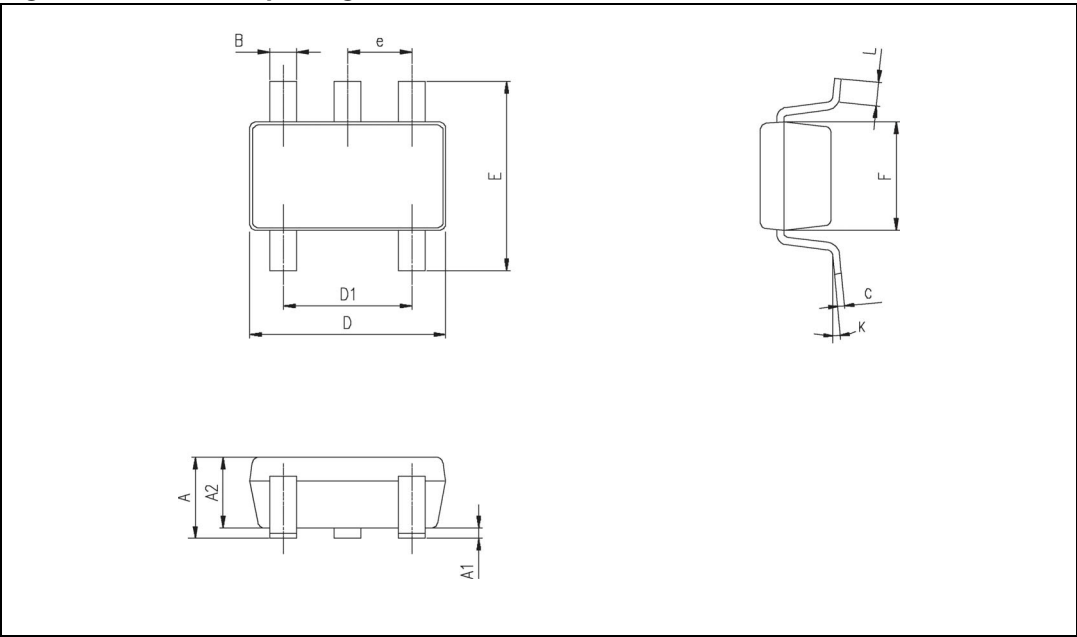
Table 9.   SOT23-5 package mechanical data

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			

4 Ordering information

Table 10. Order codes

Order code	Temperature range	Package	Packaging	Marking
TS931ID TS931IDT TS931AID TS931AIDT TS931BID TS931BIDT		SO-8	Tube Tape and reel Tube Tape and reel Tube Tape and reel	931I 931I 931AI 931AI 931BI 931BI
TS931ILT TS931AILT TS931BILT		SOT23-5L	Tape and reel	K205 K206 K207
TS932ID TS932IDT TS932AID TS932AIDT TS932BID TS932BIDT	-40 °C, +105 °C	SO-8	Tube Tape and reel Tube Tape and reel Tube Tape and reel	932I 932I 932AI 932AI 932BI 932BI
TS934ID TS934IDT TS934AID TS934AIDT TS934BIDT TS934BIDT		SO-14	Tube Tape and reel Tube Tape and reel Tube Tape and reel	934I 934I 934AI 934AI 934BI 934BI
TS934IPT TS934AIPT TS934BIPT		TSSOP-14 (thin shrink outline package)	Tape and reel	934I 934AI 934BI
TS934IYDT[1] TS934AIYDT[1]		SO-14 (automotive grade)	Tape and reel	934IY 934AIY

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
01-Nov-2001	1	Initial release.
01-Dec-2004	2	Modified AMR values in *Table 2* (explanation of Vid and Vi limits).
04-May-2009	3	Document reformatted. Removed DIP package information and order codes from *Chapter 3*. Modified temperature range: extended to -40 to +105° C in *Table 10: Order codes*. Added automotive grade products in *Table 10*.
07-Sep-2009	4	Added root part numbers (TS93xA, TS93xB) and *Table 1: Device summary* on cover page. Added parameters for full temperature range in *Table 4* and in *Table 5*.
07-Nov-2012	5	Updated *Features* (added SO-8, SO-14, and TSSOP-14 package). Updated *Table 2* (removed TSSOP8 package). Removed TS934IYD and TS934AIYD order codes from *Table 10*, qualified status of TS934IYDT and TS934AIYDT order codes in *Table 10*. Minor corrections throughout document.

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