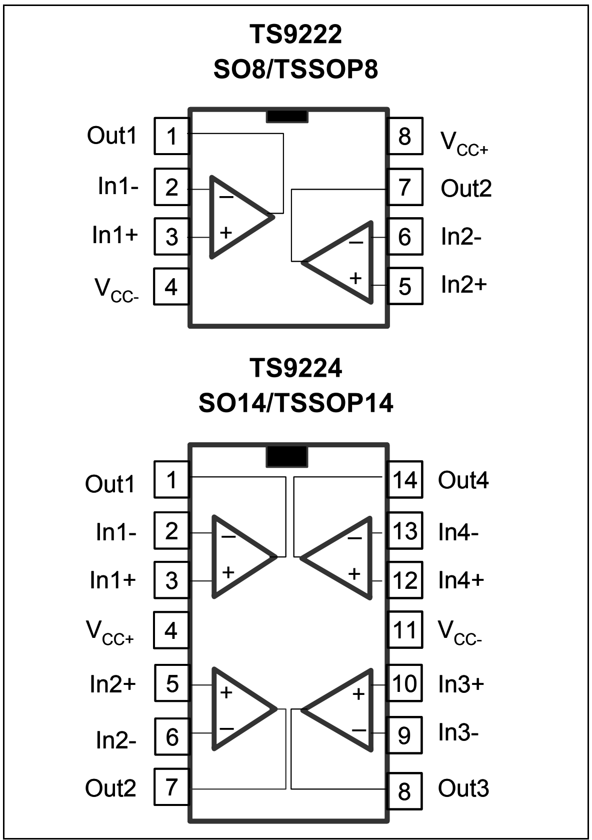
TS9222, TS9224

HIgh precision high stability dual and quad operational amplifiers

Datasheet - production data



Features

- High precision: Vio = 500 µV max
- Able to drive capacitive loads up to 500 pF
- Rail-to-rail input and output
- Low noise: 9 nV/√Hz
- Low distortion
- High output current: 80 mA
- High speed: 4 MHz, 1.3 V/µs
- Operates from 2.7 V to 12 V
- ESD internal protection: 2 kV
- Latch-up immunity
- Automotive qualification

Applications

- Signal conditioning
- Automotive applications
- Headphone amplifiers
- Sound cards, multimedia systems
- Line and actuator drivers
- Servo amplifiers

Description

The TS9222 and TS9224 are rail-to-rail dual and quad operational amplifiers optimized for precision, noise and stability, which make them suitable for a wide range of automotive and industrial applications.

These devices deliver a high output current that allows low-load impedances to be driven. They are stable for capacitive loads up to 500 pF.

Contents

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_{CC-} -0.3 to V_{CC+} +0.3	V
T_{stg}	Storage temperature	-65 to +150	°C
R_{thja}	Thermal resistance junction to ambient(4) SO8 TSSOP8 SO14 TSSOP14	 125 120 66 100	°C/W
T_j	Maximum junction temperature	150	°C
ESD TS9222	HBM: human body model(5)	2000	V
	MM: machine model(6)	120	V
	CDM: charged device model(7)	1500	V
ESD TS9224	HBM: human body model(5)	3	kV
	MM: machine model(6)	100	V
	CDM: charged device model(7) SO14 TSSOP14	 1.5 1	kV
	Output short circuit duration	see note(8)	
	Latch-up immunity	200	mA
	Soldering temperature (10 sec), unleaded version	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. Destructive dissipation can result from simultaneous short-circuits on all amplifiers. These 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 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.
8. There is no short-circuit protection inside the device: short-circuits from the output to V_{CC} can cause excessive heating. The maximum output current is approximately 80mA, independent of the magnitude of V_{CC}. Destructive dissipation can result from simultaneous short-circuits on all amplifiers.

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_{CC-} -0.2 to V_{CC+} +0.2	
T_{oper}	Operating free air temperature range	-40 to +125	°C

2 Electrical characteristics

Table 3. Electrical characteristics measured at V_{CC+} = +3 V, V_{CC-} = 0 V, V_{icm} = V_{CC}/2, T_{amb} = 25° C, and R_L connected to V_{CC}/2 (unless otherwise specified)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V_{io}	Input offset voltage				500	µV
		$T_{min} \leq T_{amb} \leq T_{max}$			900	
$\Delta V_{io}/\Delta T$	Input offset voltage drift			2		µV/°C
I_{io}	Input offset current	$V_{out} = V_{CC}/2$, $T_{min} \leq T_{amb} \leq T_{max}$		1	30	nA
I_{ib}	Input bias current	$V_{out} = V_{CC}/2$ $T_{min} \leq T_{amb} \leq T_{max}$		15	55 90	
CMR	Common mode rejection ratio	V_{icm} from 0 to 3 V $T_{min} \leq T_{amb} \leq T_{max}$	65 60	85		dB
SVR	Supply voltage rejection ratio	V_{CC} = 2.7 to 3.3 V $T_{min} \leq T_{amb} \leq T_{max}$	75 70	90		
A_{vd}	Large signal voltage gain	R_L= 10 kΩ, V_{out} = 2 V_{p-p}	70	200		V/mV
		R_L = 600 Ω, V_{out} = 2 V_{p-p} $T_{min} \leq T_{amb} \leq T_{max}$	15 1.8	35		
V_{OH}	High level output voltage	R_L= 10 kΩ, $T_{min} \leq T_{amb} \leq T_{max}$	2.90			V
		R_L = 600 Ω, $T_{min} \leq T_{amb} \leq T_{max}$	2.87			
V_{OL}	Low level output voltage	R_L= 10 kΩ, $T_{min} \leq T_{amb} \leq T_{max}$			50	mV
		R_L = 600 Ω, $T_{min} \leq T_{amb} \leq T_{max}$			100	
I_o	Output short circuit current		50	80		mA
I_{CC}	Supply current (per channel)	No load, Vout = V_{CC}/2 $T_{min} \leq T_{amb} \leq T_{max}$		0.9	1.2 1.3	
GBP	Gain bandwidth product	R_L = 10 kΩ, C_L = 100 pF		4		MHz
SR	Slew rate		0.7	1.3		V/µs
ϕm	Phase margin at unit gain			60		Degrees
G_m	Gain margin			8.5		dB
e_n	Equivalent input noise voltage	f = 1 kHz		9		$\frac{nV}{\sqrt{Hz}}$
THD	Total harmonic distortion	V_{out} = 2 V_{p-p}, f = 1 kHz, A_v = 1, R_L = 600 Ω		0.005		%
C_s	Channel separation			120		dB

Table 4. Electrical characteristics measured at V_{CC+} = 5 V, V_{CC-} = 0 V, V_{icm} = V_{CC}/2, T_{amb} = 25° C, and R_L connected to V_{CC}/2 (unless otherwise specified)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V_{io}	Input offset voltage				500	µV
		$T_{min} \leq T_{amb} \leq T_{max}$			900	
$\Delta V_{io}/\Delta T$	Input offset voltage drift			2		µV/°C
I_{io}	Input offset current	$V_{out} = V_{CC}/2$, $T_{min} \leq T_{amb} \leq T_{max}$		1	30	nA
I_{ib}	Input bias current	$V_{out} = V_{CC}/2$ $T_{min} \leq T_{amb} \leq T_{max}$		15	55 90	
CMR	Common mode rejection ratio	V_{icm} from 0 to 5 V $T_{min} \leq T_{amb} \leq T_{max}$	65 60	85		dB
SVR	Supply voltage rejection ratio	V_{CC} = 4.5 to 5.5 V $T_{min} \leq T_{amb} \leq T_{max}$	75 70	90		
A_{vd}	Large signal voltage gain	R_L= 10 kΩ, V_{out} = 2 V_{p-p}	70	200		V/mV
		R_L = 600 Ω, V_{out} = 2 V_{p-p} $T_{min} \leq T_{amb} \leq T_{max}$	24 3	35		
V_{OH}	High level output voltage	R_L = 10 kΩ, $T_{min} \leq T_{amb} \leq T_{max}$	4.9			V
		R_L = 600 Ω, $T_{min} \leq T_{amb} \leq T_{max}$	4.85			
V_{OL}	Low level output voltage	R_L = 10 kΩ, $T_{min} \leq T_{amb} \leq T_{max}$			50	mV
		R_L = 600 Ω, $T_{min} \leq T_{amb} \leq T_{max}$			120	
I_o	Output short circuit current		50	80		mA
I_{cc}	Supply current (per channel)	No load, Vout = VCC/2 $T_{min} \leq T_{amb} \leq T_{max}$		0.9	1.2 1.3	
GBP	Gain bandwidth product	RL = 10 kΩ, CL = 100 pF		4		MHz
SR	Slew rate		0.7	1.3		V/µs
ϕm	Phase margin at unit gain			63		Degrees
G_m	Gain margin			9.5		dB
e_n	Equivalent input noise voltage	f = 1 kHz		9		$\frac{nV}{\sqrt{Hz}}$
THD	Total harmonic distortion	V_{out} = 2 V_{p-p}, f = 1 kHz, A_v = 1, R_L = 600 Ω		0.005		%
C_s	Channel separation			120		dB

Figure 1. Total supply current vs. supply voltage

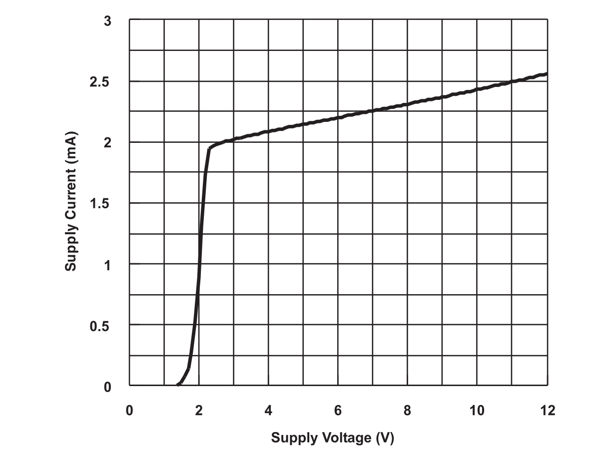


Figure 2. Output short circuit current vs. output voltage

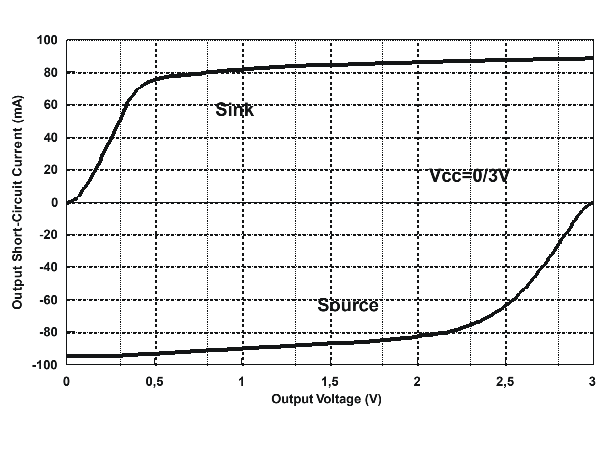


Figure 3. Voltage gain and phase vs. frequency, C_L = 100 pF

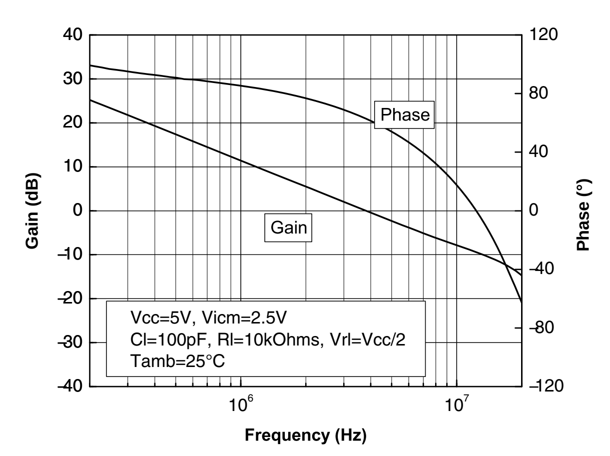


Figure 4. Voltage gain and phase vs. frequency, C_L = 500 pF

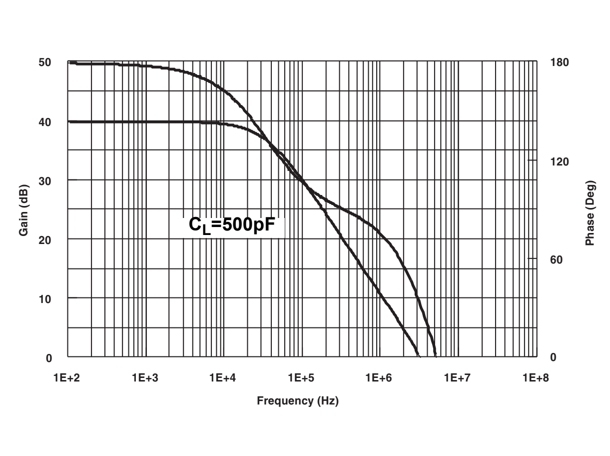


Figure 5. Equivalent input noise voltage vs. frequency

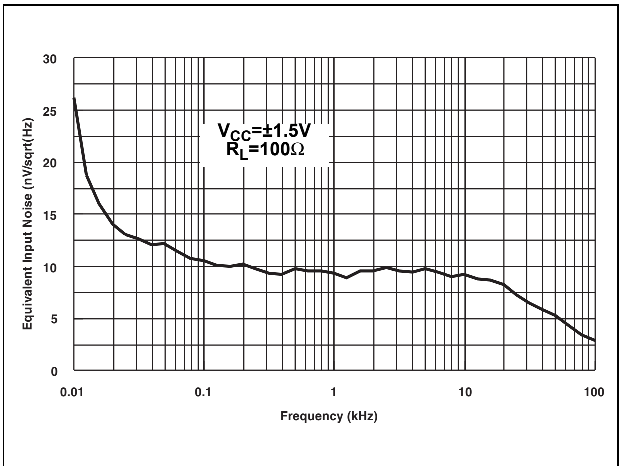


Figure 6. THD + noise vs. frequency, R_L = 2 kΩ, Vo = 10 Vpp

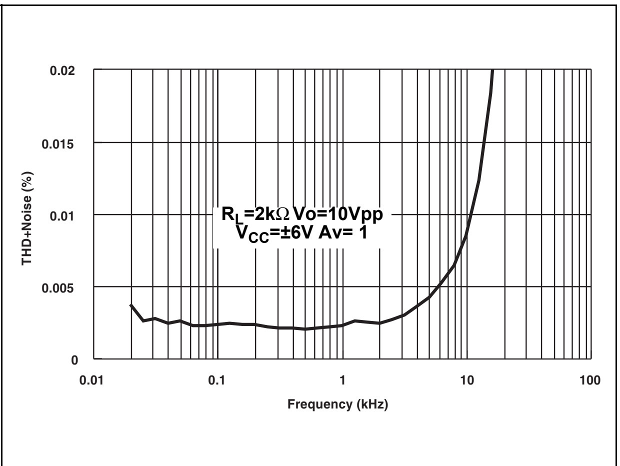


Figure 7. THD + noise vs. frequency, R_L = 32 Ω, Vo = 4 Vpp

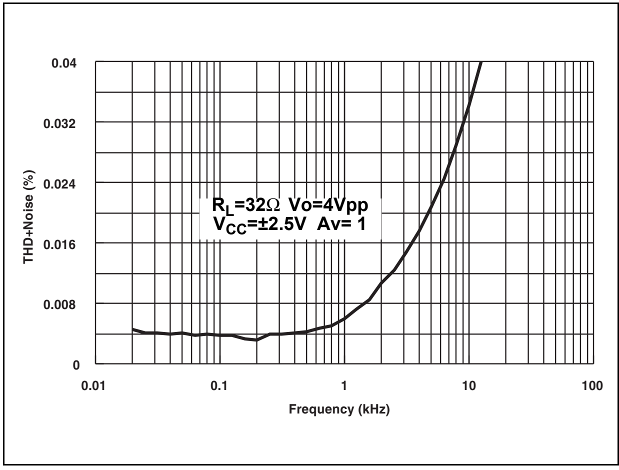


Figure 8. THD + noise vs. frequency, R_L = 32 Ω, Vo = 2 Vpp

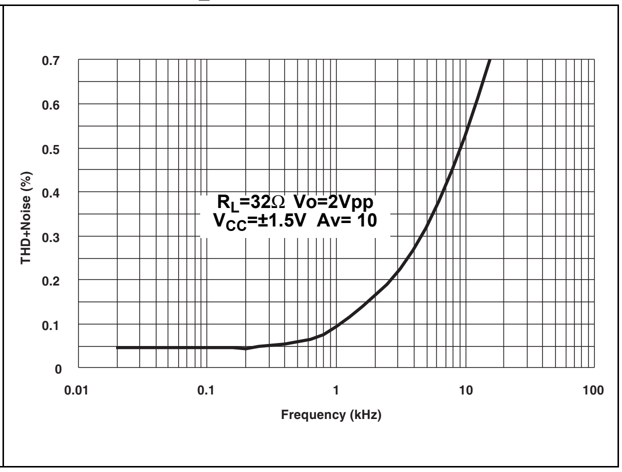


Figure 9. THD + noise vs. output voltage, R_L = 600 Ω, f = 1 kHz

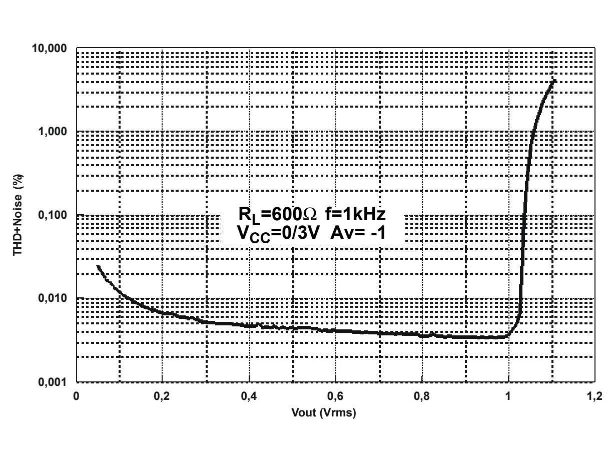


Figure 10. THD + noise vs. output voltage, R_L = 32 Ω, f = 1 kHz

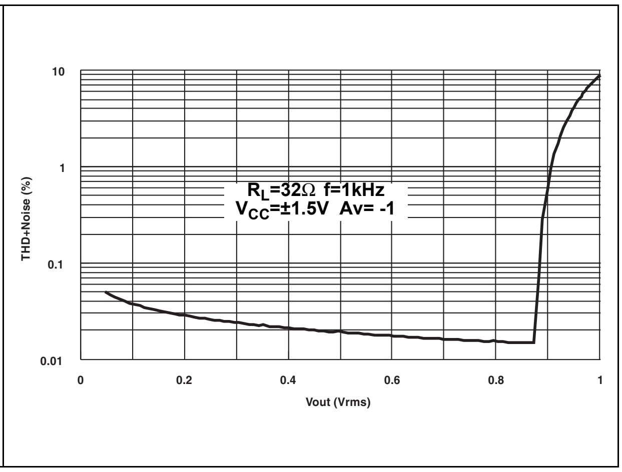
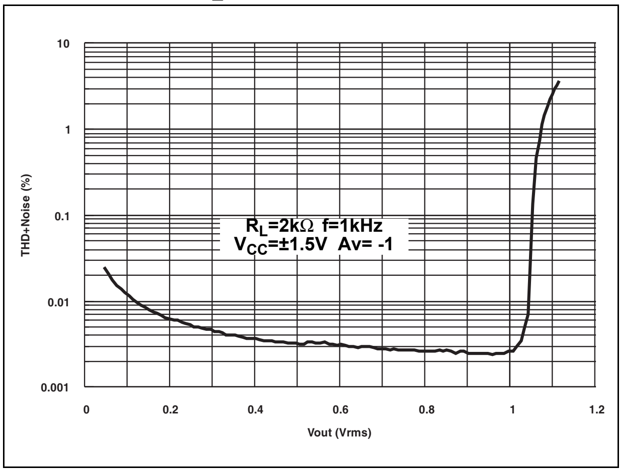


Figure 11. THD + noise vs. output voltage, R_L = 2 kΩ, f = 1 kHz



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 SO8 package information

Figure 12. SO8 package mechanical drawing

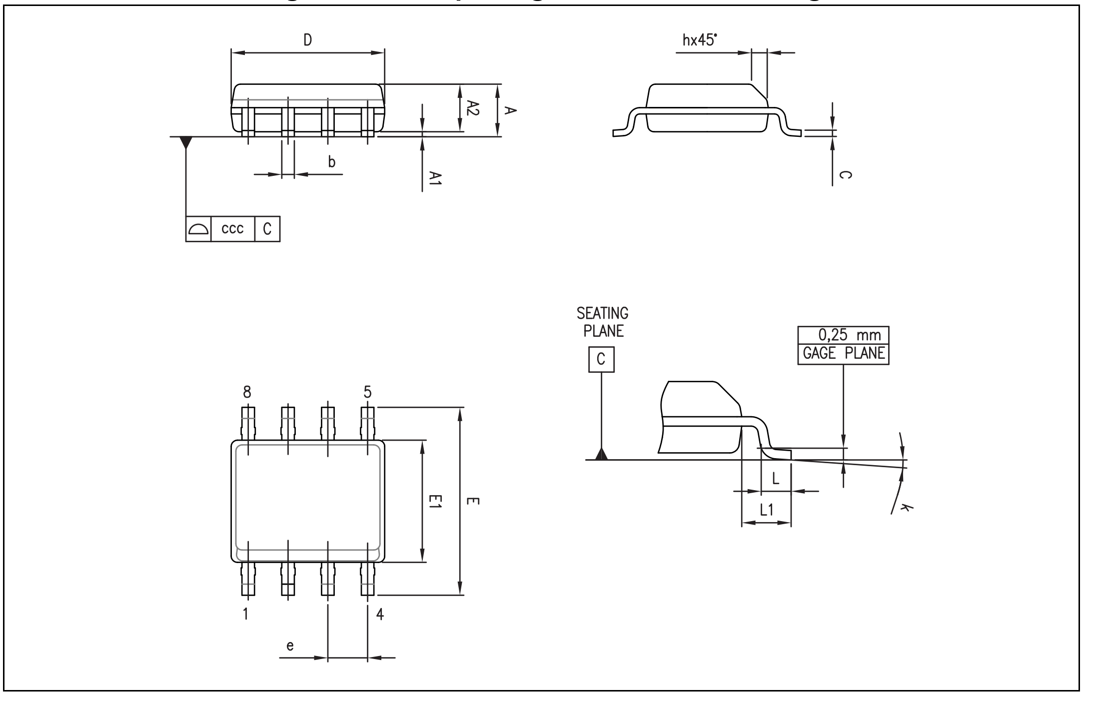


Table 5. SO8 package mechanical data

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
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

3.2 TSSOP8 package information

Figure 13. TSSOP8 package mechanical drawing

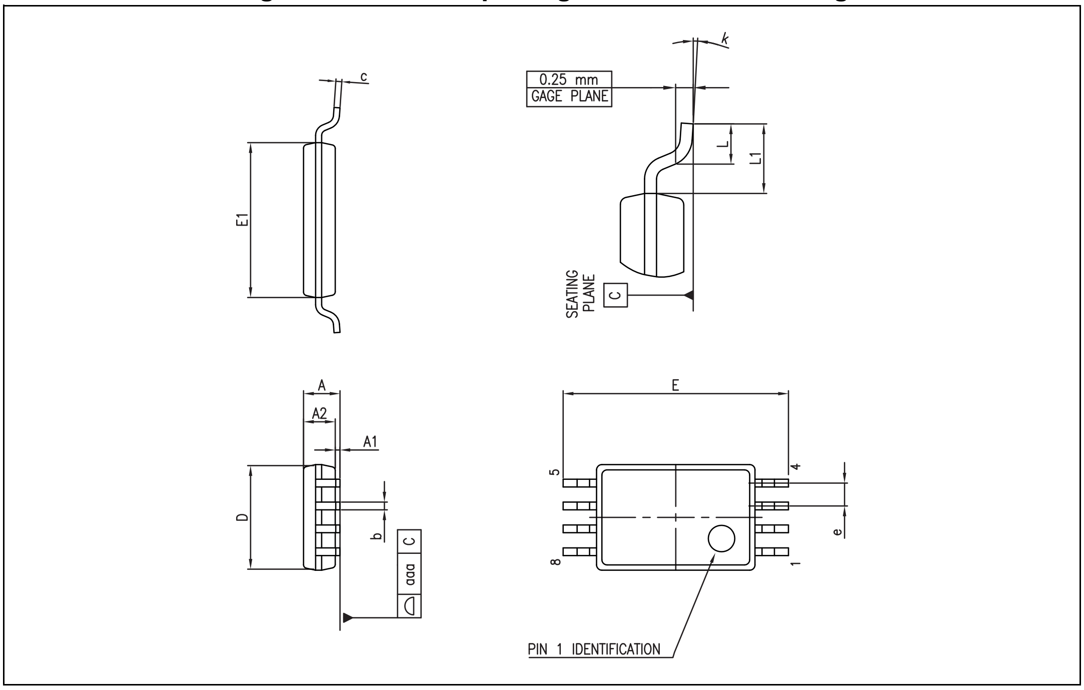


Table 6. TSSOP8 package mechanical data

Ref.	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

3.3 SO14 package information

Figure 14. SO14 package mechanical drawing

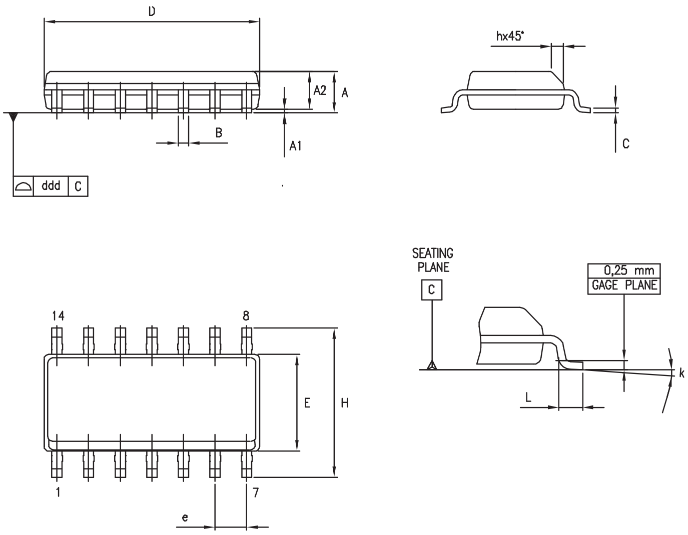


Table 7. SO14 package mechanical data

Ref.	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

3.4 TSSOP14 package information

Figure 15. TSSOP14 package mechanical drawing

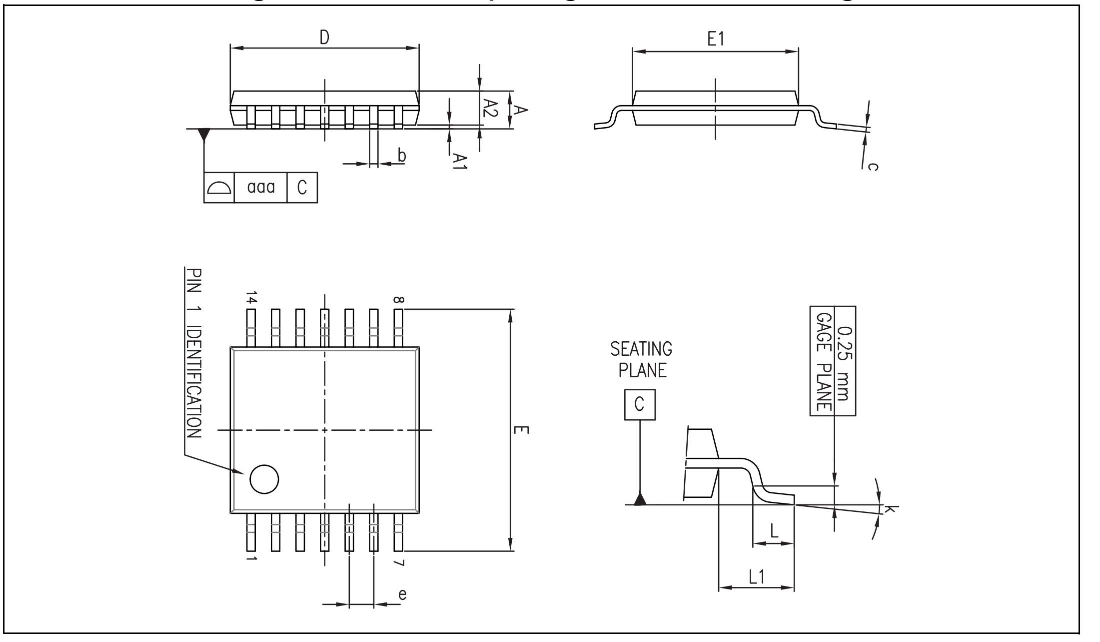


Table 8. TSSOP14 package mechanical data

Ref.	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 9. Order codes

Order code	Temperature range	Package	Packaging	Marking
TS9222ID TS9222IDT	-40° C, +125° C	SO8	Tube or Tape and reel	9222
TS9222IPT		TSSOP8	Tape and reel	
TS9224ID TS9224IDT		SO14	Tube or Tape and reel	9224
TS9224IPT		TSSOP14	Tape and reel	
TS9222IYDT(1)		SO8 (automotive grade)		9222Y
TS9222IYPT(1)		TSSOP8 (automotive grade)		
TS9224IYDT(1)		SO14 (automotive grade)		9224Y
TS9224IYPT(1)		TSSOP14 (automotive grade)		

1. 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 10. Document revision history

Date	Revision	Changes
25-Sep-2009	1	Initial release.
18-Mar-2010	2	Added pinout of dual and quad versions on cover page. Corrected AVd parameter values in *Table 3.* and *Table 4.*
13-Apr-2011	3	Updated test conditions for CMR in *Table 3.* and *Table 4.*
31-May-2013	4	Added "automotive qualification" to *Features* *Table 1*: updated ESD values *Table 3* and *Table 4*: updated $DV_{io}$with $\Delta V_{io}/\Delta T$, updated I_{CC} parameter. *Table 9*: updated footnotes
23-May-2014	5	*Table 3* and *Table 4*: added minimum slew rate (SR) values Updated disclaimer