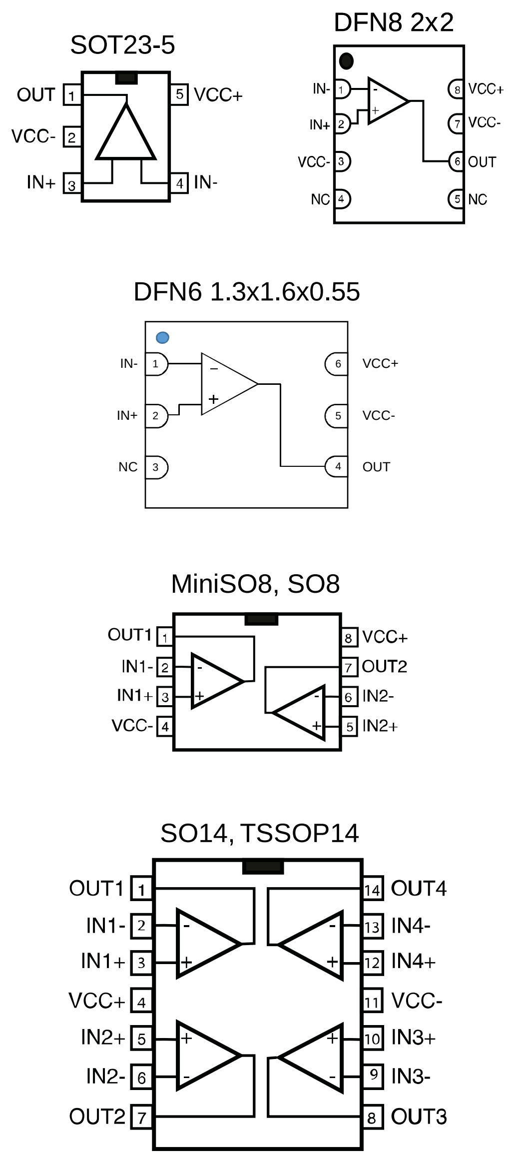
TSV991, TSV992, TSV994
TSV991A, TSV992A, TSV994A

Rail-to-rail input/output 20 MHz GBP operational amplifiers

Datasheet - production data

Pin connections
(top view)



Features

- Low input offset voltage: 1.5 mV max (A grade)
- Rail-to-rail input and output
- Wide bandwidth 20 MHz
- Stable for gain ≥ 4 or ≤ -3
- Low power consumption: 820 µA typ
- High output current: 35 mA
- Operating from 2.5 V to 5.5 V
- Low input bias current, 1 pA typ
- ESD internal protection ≥ 5 kV

Related products

- See TSV911, TSV912, and TSV914 for unity-gain stable amplifiers

Applications

- Battery-powered applications
- Portable devices
- Signal conditioning and active filtering
- Medical instrumentation
- Automotive applications

Description

The TSV99x and TSV99xA family of single, dual, and quad operational amplifiers offers low voltage operation and rail-to-rail input and output. These devices feature an excellent speed/power consumption ratio, offering a 20 MHz gain-bandwidth, stable for gains above 4 (100 pF capacitive load), while consuming only 1.1 mA maximum at 5 V. They also feature an ultra-low input bias current. These characteristics make the TSV99x family ideal for sensor interfaces, battery-supplied and portable applications, as well as active filtering. These characteristics make the TSV99x, TSV99xA family ideal for sensor interfaces, battery-supplied and portable applications, as well as active filtering.

Contents

1 Absolute maximum ratings and operating conditions

Table 1: Absolute maximum ratings (AMR)

Symbol	Parameter		Value	Unit
V_{CC}	Supply voltage (1)		6	V
V_{id}	Differential input voltage (2)		$\pm V_{CC}$	
V_{in}	Input voltage (3)		(V_{CC-}) - 0.2 to (V_{CC+}) + 0.2	
I_{in}	Input current (4)		10	mA
T_{stg}	Storage temperature		-65 to 150	°C
T_j	Maximum junction temperature		150	
R_{thja}	Thermal resistance junction to ambient (5)(6)	DFN8 2x2	57	°C/W
		DFN6 1.3x1.6x0.55	230	
		SOT23-5	250	
		SO8	125	
		MiniSO8	190	
		SO14	103	
		TSSOP14	100	
R_{thjc}	Thermal resistance junction to case	SOT23-5	81	
		SO8	40	
		MiniSO8	39	
		SO14	31	
		TSSOP14	32	
ESD	HBM: human body model (7)		5	kV
	MM: machine model (8)		400	V
	CDM: charged device model (9)	SOT23-5, SO8, MiniSO8, DFN8 2x2	1500	
		DFN6 1.3x1.6x0.55	TBD	
		TSSOP14	750	
		SO14	500	
	Latch-up immunity		200	mA

Notes:

(1) Value is with respect to the V_{CC-} pin

(2) Differential voltages are the non-inverting input terminal with respect to the inverting input terminal

(3) V_{CC} - V_{IN} must not exceed 6 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) R_{th} are typical values

(7) Human body model: 100 pF discharged through a 1.5 kΩ resistor between two pins of the device, done for all couples of pin combinations with other pins floating.

[8]Machine model: 200 pF charged to the specified voltage, then discharged directly between two pins of the device with no external series resistor (internal resistor < 5 Ω), done for all couples of pin combinations with other pins floating

[9]Charged device model: all pins plus packages are charged together to the specified voltage and then discharged directly to the ground.

Table 2: Operating conditions

Symbol	Parameter	Value	Unit
V_{CC}	Supply voltage	2.5 to 5.5	V
V_{icm}	Common mode input voltage range	$(V_{CC-}) - 0.1$ to $(V_{CC+}) + 0.1$	
T_{op}	Operating free air temperature range	-40 to 125	°C

2 Electrical characteristics

In the electrical characteristic tables below, all parameter limits at temperatures other than 25 °C are guaranteed by correlation

Table 3: Electrical characteristics at VCC+ = 2.5 V, VCC- = 0 V, Vicm = VCC/2, and RL connected to VCC/2, full temperature range (unless otherwise specified)

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
DC performance						
V_{io}	Offset voltage TSV99x	T_{op} = 25 °C		0.1	4.5	mV
		$T_{min} < T_{op} < T_{max}$			7.5	
	Offset voltage TSV99xA	T_{op} = 25 °C			1.5	
		$T_{min} < T_{op} < T_{max}$			3	
$\Delta V_{io}/\Delta T$	Input offset voltage drift			2		µV/°C
I_{io}	Input offset current, ($V_{out} = V_{CC}/2$) (1)	T_{op} = 25 °C		1	10	pA
		$T_{min} < T_{op} < T_{max}$			100	
I_{ib}	Input bias current, ($V_{out} = V_{CC}/2$) (1)	T_{op} = 25 °C		1	10	
		$T_{min} < T_{op} < T_{max}$			100	
CMR	Common mode rejection ratio, 20 log ($\Delta V_{ic}/\Delta V_{io}$)	0 V to 2.5 V, V_{out} = 1.25 V, T_{op} = 25 °C	58	75		dB
		$T_{min} < T_{op} < T_{max}$	53			
A_{vd}	Large signal voltage gain	R_L= 10 kΩ, V_{out} = 0.5 V to 2 V, T_{op} = 25 °C	80	89		
		$T_{min} < T_{op} < T_{max}$	75			
V_{CC} - V_{OH}	High level output voltage	R_L = 10 kΩ, $T_{min} < T_{op} < T_{max}$		15	40	mV
		R_L = 600 kΩ, $T_{min} < T_{op} < T_{max}$		45	150	
V_{OL}	Low level output voltage	R_L = 10 kΩ, $T_{min} < T_{op} < T_{max}$		15	40	
		R_L = 600 kΩ, $T_{min} < T_{op} < T_{max}$		45	150	
I_{out}	I_{sink}	V_o = 2.5 V, T_{op} = 25 °C	18	32		mA
		$T_{min} < T_{op} < T_{max}$	16			
	I_{source}	V_o = 0 V, T_{op} = 25 °C	18	35		
		$T_{min} < T_{op} < T_{max}$	16			
I_{CC}	Supply current (per channel)	No load, $V_{out} = V_{CC}/2$, $T_{min} < T_{op} < T_{max}$		0.78	1.1	
AC performance						
GBP	Gain bandwidth product	R_L = 2 kΩ, C_L = 100 pF, f = 100 kHz, T_{op} = 25 °C		20		MHz
Gain	Minimum gain for stability	Phase margin = 45 °, R_f = 10 kΩ, R_L = 2 kΩ, C_L = 100 pF, T_{op} = 25 °C, positive gain configuration		4		V/V

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
Gain	Minimum gain for stability	Phase margin = 45 °, R_f = 10 kΩ, R_L = 2 kΩ, C_L = 100 pF, T_{op} = 25 °C, negative gain configuration		-3		V/V
SR	Slew rate	R_L = 2 kΩ, C_L = 100 pF, T_{op} = 25 °C		10		V/μs
e_n	Equivalent input noise voltage	f = 10 kHz, T_{op} = 25 °C		21		nV/√Hz
THD+N	Total harmonic distortion	G = -3, f = 1 kHz, R_L = 2 kΩ, Bw = 22 kHz, V_{icm} = V_{CC}/2, V_{out} = 2 V_{pp}, T_{op} = 25 °C		0.0025		%

Notes:

(1)Guaranteed by design

Table 4: Electrical characteristics at VCC+ = 3.3 V, VCC- = 0 V, Vicm = VCC/2, and RL connected to VCC/2, full temperature range (unless otherwise specified)

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
DC performance						
V_{io}	Offset voltage TSV99x	T_{op} = 25 °C		0.1	4.5	mV
		$T_{min} < T_{op} < T_{max}$			7.5	
	Offset voltage TSV99xA	T_{op} = 25 °C			1.5	
		$T_{min} < T_{op} < T_{max}$			3	
$\Delta V_{io}/\Delta T$	Input offset voltage drift			2		μV/°C
I_{io}	Input offset current, (V_{out} = V_{CC}/2) (1)	T_{op} = 25 °C		1	10	pA
		$T_{min} < T_{op} < T_{max}$			100	
I_{ib}	Input bias current, (V_{out} = V_{CC}/2) (1)	T_{op} = 25 °C		1	10	
		$T_{min} < T_{op} < T_{max}$			100	
CMR	Common mode rejection ratio, 20 log ($\Delta V_{ic}/\Delta V_{io}$)	0 V to 3.3 V, V_{out} = 1.65 V, T_{op} = 25 °C	60	78		dB
		$T_{min} < T_{op} < T_{max}$	55			
A_{vd}	Large signal voltage gain	R_L= 10 kΩ, V_{out} = 0.5 V to 2.8 V, T_{op} = 25 °C	80	90		
		$T_{min} < T_{op} < T_{max}$	75			
V_{CC} - V_{OH}	High level output voltage	R_L = 10 kΩ, $T_{min} < T_{op} < T_{max}$		15	40	mV
		R_L = 600 kΩ, $T_{min} < T_{op} < T_{max}$		45	150	
V_{OL}	Low level output voltage	R_L = 10 kΩ, $T_{min} < T_{op} < T_{max}$		15	40	
		R_L = 600 kΩ, $T_{min} < T_{op} < T_{max}$		45	150	
I_{out}	I_{sink}	V_o = 3.3 V, T_{op} = 25 °C	18	32		mA
		$T_{min} < T_{op} < T_{max}$	16			
	I_{source}	V_o = 0 V, T_{op} = 25 °C	18	35		
		$T_{min} < T_{op} < T_{max}$	16			
I_{CC}	Supply current (per channel)	No load, V_{out} = V_{CC}/2, $T_{min} < T_{op} < T_{max}$		0.8	1.1	
AC performance						
GBP	Gain bandwidth product	R_L = 2 kΩ, C_L = 100 pF, f = 100 kHz, T_{op} = 25 °C		20		MHz
Gain	Minimum gain for stability	Phase margin = 45 °, R_f = 10 kΩ, R_L = 2 kΩ, C_L = 100 pF, T_{op} = 25 °C, positive gain configuration		4		V/V
		Phase margin = 45 °, R_f = 10 kΩ, R_L = 2 kΩ, C_L = 100 pF, T_{op} = 25 °C, negative gain configuration		-3		
SR	Slew rate	R_L = 2 kΩ, C_L = 100 pF, f = 100 kHz, T_{op} = 25 °C		10		V/μs

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
e_n	Equivalent input noise voltage	f = 10 kHz, T_{op} = 25 °C		21		nV/√Hz
THD+N	Total harmonic distortion	G = -3, f = 1 kHz, R_L = 2 kΩ, Bw = 22 kHz, V_{icm} = V_{CC}/2, V_{out} = 2.8 V_{pp}, T_{op} = 25 °C		0.0018		%

Notes:

(1)Guaranteed by design

Table 5: Electrical characteristics at VCC+ = 5 V, VCC- = 0 V, Vicm = VCC/2, and RL connected to VCC/2, full temperature range (unless otherwise specified)

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
DC performance						
V_{io}	Offset voltage TSV99x	T_{op} = 25 °C		0.1	4.5	mV
		$T_{min} < T_{op} < T_{max}$			7.5	
	Offset voltage TSV99xA	T_{op} = 25 °C			1.5	
		$T_{min} < T_{op} < T_{max}$			3	
$\Delta V_{io}/\Delta T$	Input offset voltage drift			2		μV/°C
I_{io}	Input offset current, ($V_{out} = V_{CC}/2$) (1)	T_{op} = 25 °C		1	10	pA
		$T_{min} < T_{op} < T_{max}$			100	
I_{ib}	Input bias current, ($V_{out} = V_{CC}/2$) (1)	T_{op} = 25 °C		1	10	
		$T_{min} < T_{op} < T_{max}$			100	
CMR	Common mode rejection ratio, 20 log ($\Delta V_{ic}/\Delta V_{io}$)	0 V to 5 V, V_{out} = 2.5 V, T_{op} = 25 °C	62	82		dB
		$T_{min} < T_{op} < T_{max}$	57			
SVR	Supply voltage rejection ratio, 20 log ($\Delta V_{cc}/\Delta V_{io}$)	V_{CC} = 2.5 to 5 V	70	86		
A_{vd}	Large signal voltage gain	R_L= 10 kΩ, V_{out} = 0.5 V to 4.5 V, T_{op} = 25 °C	80	91		
		$T_{min} < T_{op} < T_{max}$	75			
V_{CC} - V_{OH}	High level output voltage	R_L = 10 kΩ, $T_{min} < T_{op} < T_{max}$		15	40	mV
		R_L = 600 kΩ, $T_{min} < T_{op} < T_{max}$		45	150	
V_{OL}	Low level output voltage	R_L = 10 kΩ, $T_{min} < T_{op} < T_{max}$		15	40	
		R_L = 600 kΩ, $T_{min} < T_{op} < T_{max}$		45	150	
I_{out}	I_{sink}	V_o = 5 V, T_{op} = 25 °C	18	32		mA
		$T_{min} < T_{op} < T_{max}$	16			
	I_{source}	V_o = 0 V, T_{op} = 25 °C	18	35		
		$T_{min} < T_{op} < T_{max}$	16			
I_{CC}	Supply current (per channel)	No load, V_{out} = 2.5 V, $T_{min} < T_{op} < T_{max}$		0.82	1.1	
AC performance						
GBP	Gain bandwidth product	R_L = 2 kΩ, C_L = 100 pF, f = 100 kHz, T_{op} = 25 °C		20		MHz
Gain	Minimum gain for stability	Phase margin = 45 °, R_f = 10 kΩ, R_L = 2 kΩ, C_L = 100 pF, T_{op} = 25 °C, positive gain configuration		4		V/V
		Phase margin = 45 °, R_f = 10 kΩ, R_L = 2 kΩ, C_L = 100 pF, T_{op} = 25 °C, negative gain configuration		-3		

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
SR	Slew rate	R_L = 2 kΩ, C_L = 100 pF, T_{op} = 25 °C		10		V/μs
e_n	Equivalent input noise voltage	f = 10 kHz, T_{op} = 25 °C		21		nV/√Hz
THD+N	Total harmonic distortion	G = -3, f = 1 kHz, R_L = 2 kΩ, Bw = 22 kHz, V_{icm} = V_{CC}/2, V_{out} = 4.4 V_{pp}, T_{op} = 25 °C		0.0014		%

Notes:

(1)Guaranteed by design

Figure 1: Input offset voltage distribution at T = 25 ° C

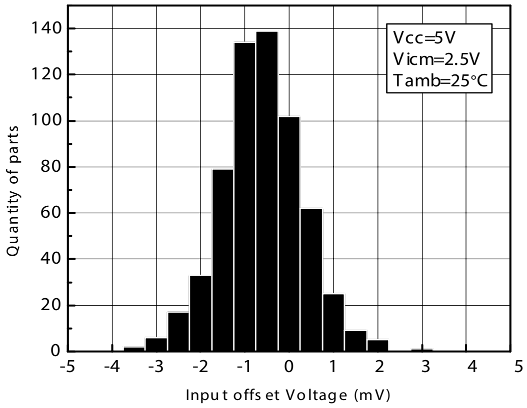


Figure 2: Input offset voltage distribution at T = 125 ° C

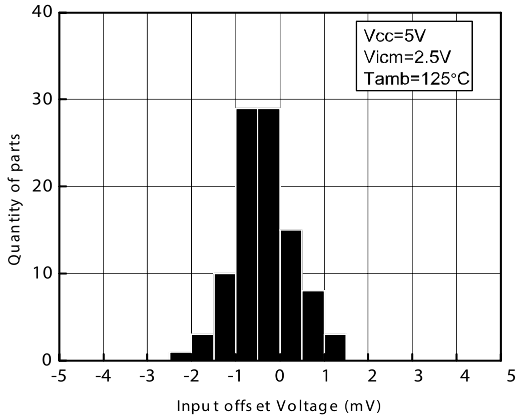


Figure 3: Supply current vs. input common mode voltage at VCC = 2.5 V

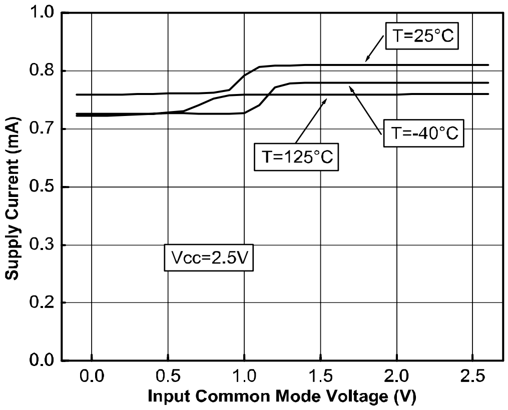


Figure 4: Supply current vs. input common mode voltage at VCC = 5 V

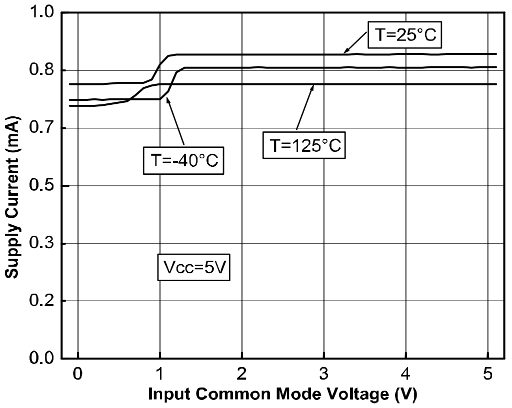


Figure 5: Output current vs. output voltage at VCC = 2.5 V

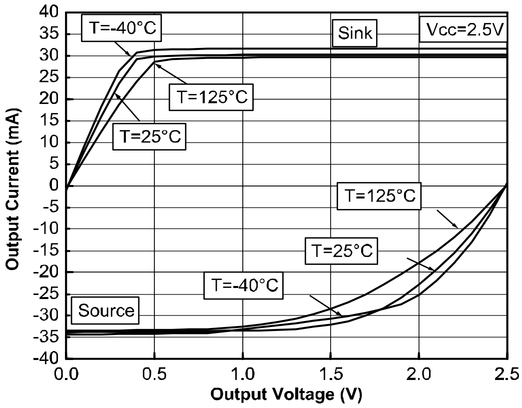


Figure 6: Output current vs. output voltage at VCC = 5 V

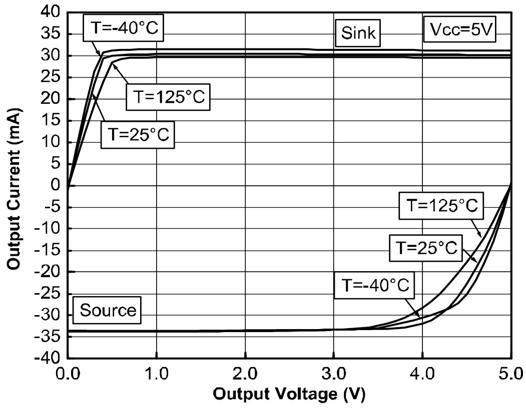


Figure 7: Voltage gain and phase vs frequency at VCC = 5 V and Vicm = 0.5 V

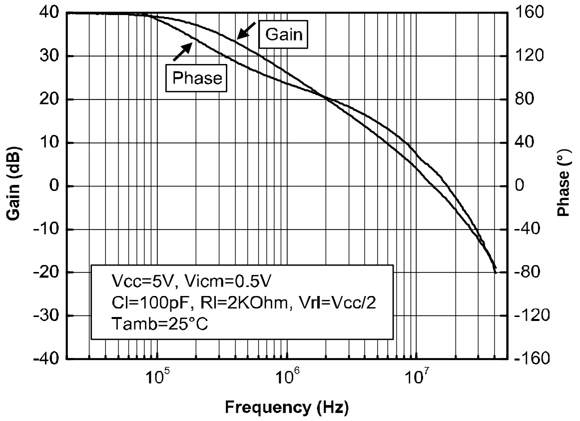


Figure 8: Voltage gain and phase vs frequency at VCC = 5 V and Vicm = 2.5 V

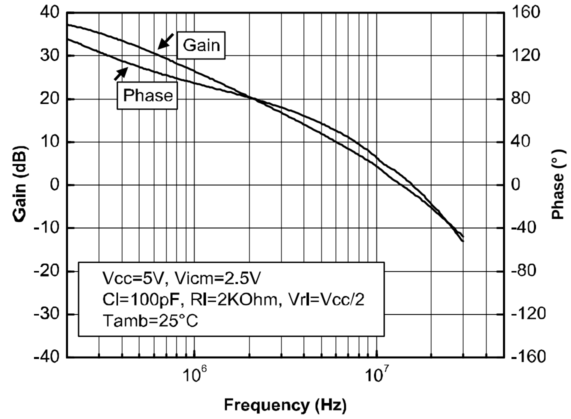


Figure 9: Positive slew rate

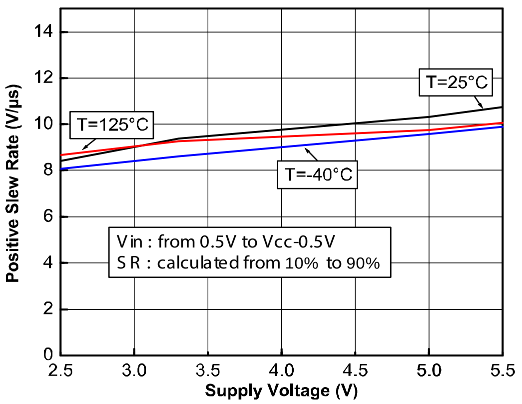


Figure 10: Negative slew rate

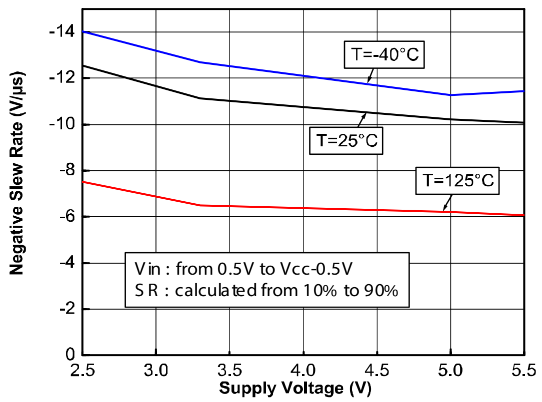


Figure 11: Distortion + noise vs. frequency

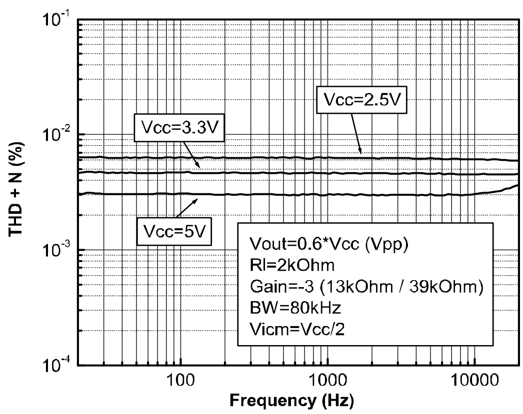


Figure 12: Distortion + noise vs. output voltage

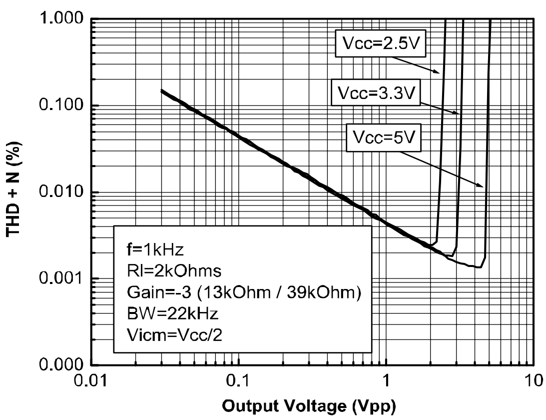


Figure 13: Noise vs. frequency

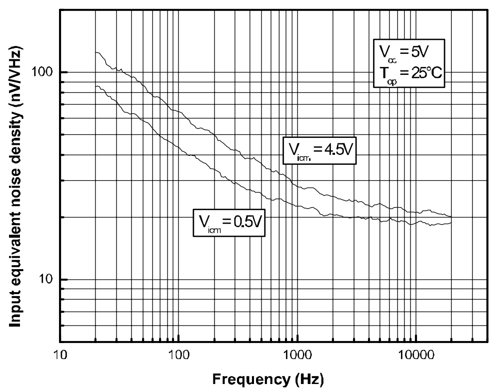
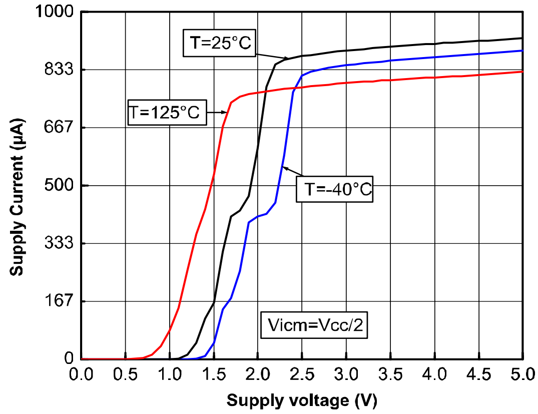


Figure 14: Supply current vs. supply voltage



3 Application information

3.1 Driving resistive and capacitive loads

These products are low-voltage, low-power operational amplifiers optimized to drive rather large resistive loads above 2 kΩ.

TSV99x products are not unity gain stable. To ensure proper stability they must be used in a gain configuration, with a minimum gain of -3 or 4.

However, they can be used in a “*follower*“ configuration by adding a small, in-series resistor at the output, which drastically improves the stability of the device (*Figure 15* shows the recommended in-series resistor values). Once the in-series resistor value has been selected, the stability of the circuit should be tested on the bench and simulated with the simulation model.

Another way to improve stability and reduce peaking is to add a capacitor in parallel with the feedback resistor. As shown in *Figure 16*, the feedback capacitor drastically reduces the peaking versus capacitive load (inverting gain configuration, gain = -2).

Figure 15: In-series resistor vs. capacitive load when TSV99x is used in follower configuration

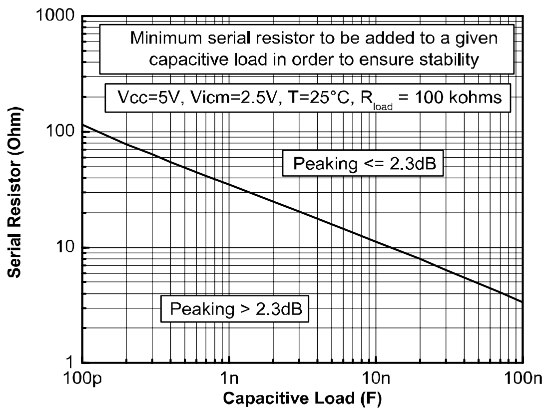
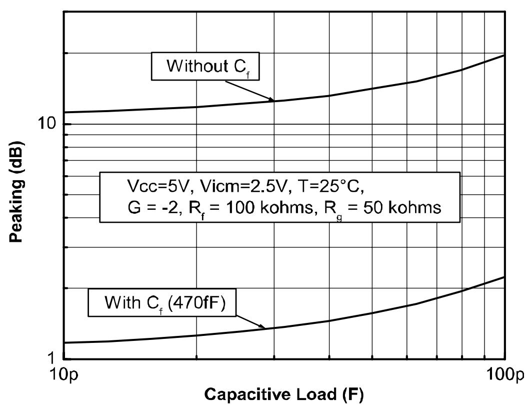


Figure 16: Peaking versus capacitive load, with or without feedback capacitor in inverting gain configuration



3.2 PCB layouts

For correct operation, it is advised to add 10 nF decoupling capacitors as close as possible to the power supply pins.

3.3 Macromodel

An accurate macromodel of the TSV99x is available on STMicroelectronics’ web site at ***www.st.com***. This model is a trade-off between accuracy and complexity (that is, time simulation) of the TSV99x operational amplifiers. It emulates the nominal performances of a typical device within the specified operating conditions mentioned in the datasheet. It helps to validate a design approach and to select the right operational amplifier, *however, it does not replace on-board measurements.*

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 17: SOT23-5 package outline

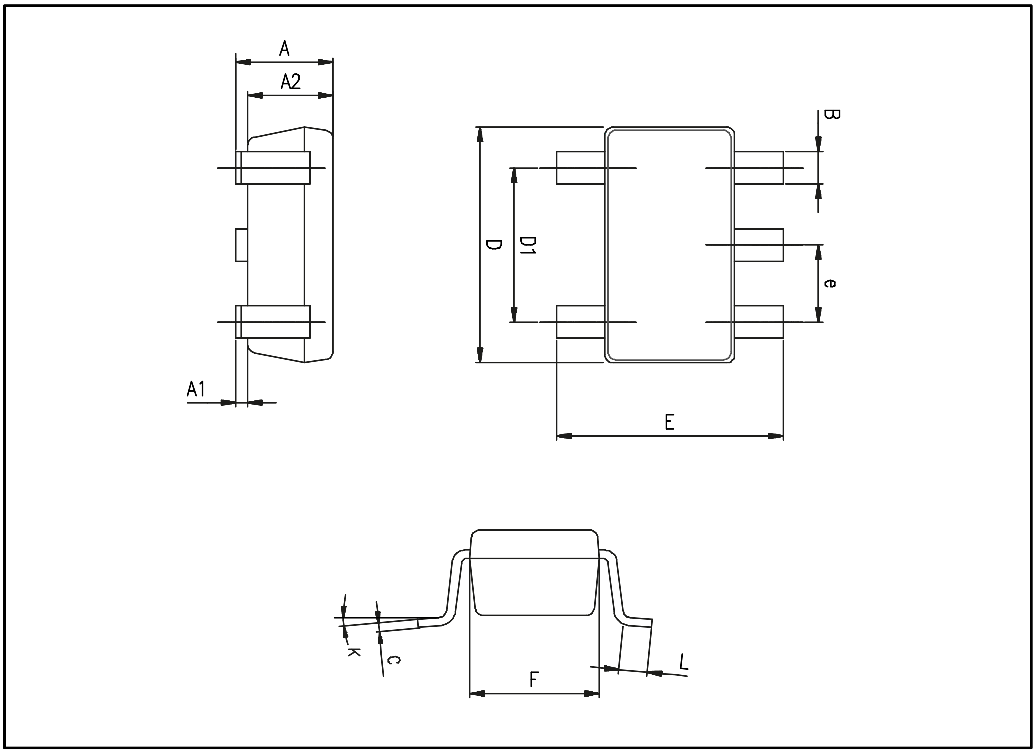


Table 6: SOT23-5 mechanical data

Ref.	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	0.014	0.016	0.020
C	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	
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	0.014	0.024
K	0 degrees		10 degrees	0 degrees		10 degrees

4.2 DFN8 2 x 2 (NB) package information

Figure 18: DFN8 2 x 2 mm (NB) package outline

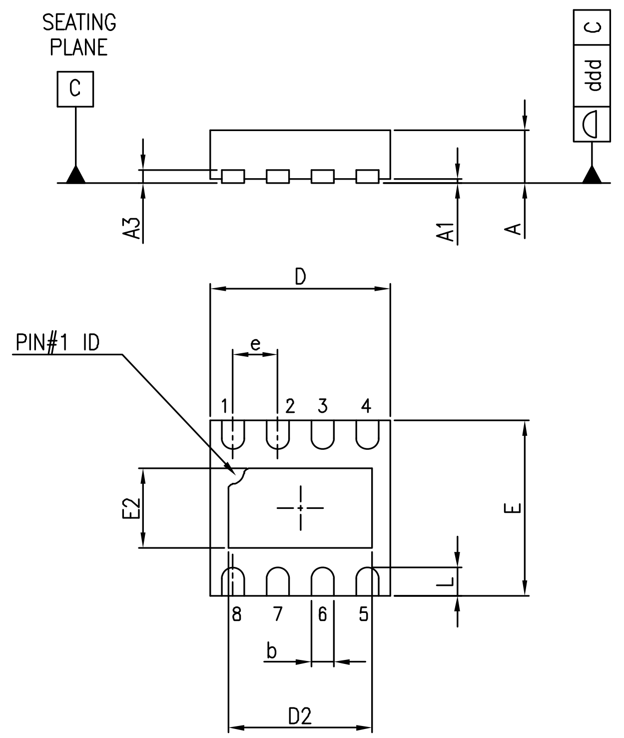
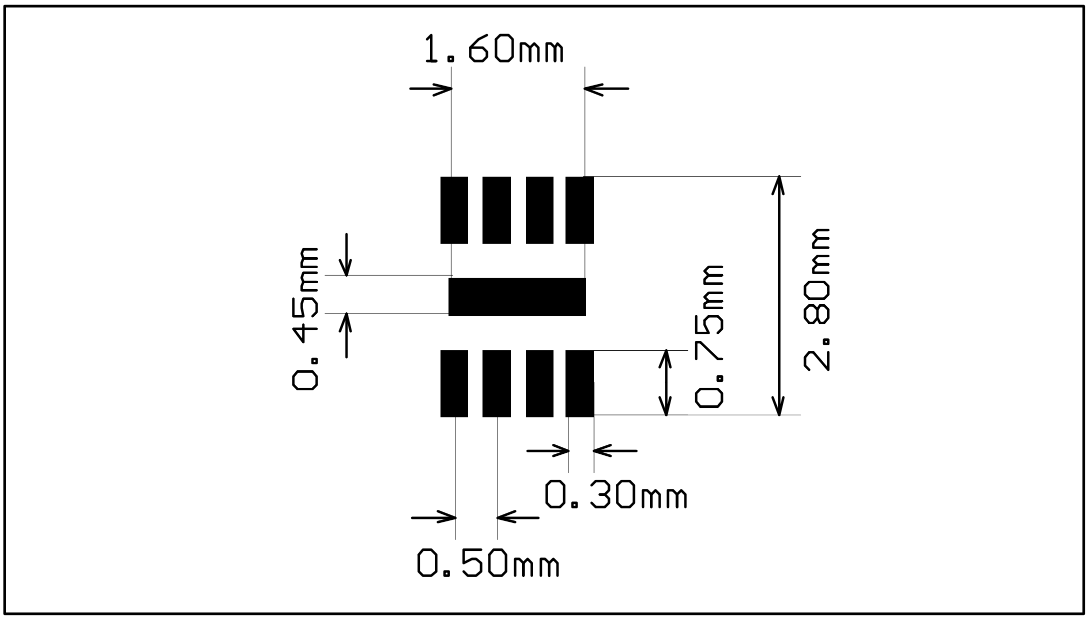


Table 7: DFN8 2 x 2 x 0.6 mm (NB) mechanical data (pitch 0.5 mm)

Ref.	Dimensions					
	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A	0.51	0.55	0.60	0.020	0.022	0.024
A1			0.05			0.002
A3		0.15			0.006	
b	0.18	0.25	0.30	0.007	0.010	0.012
D	1.85	2.00	2.15	0.073	0.079	0.085
D2	1.45	1.60	1.70	0.057	0.063	0.067
E	1.85	2.00	2.15	0.073	0.079	0.085
E2	0.75	0.90	1.00	0.030	0.035	0.039
e		0.50			0.020	
L			0.425			0.017
ddd			0.08			0.003

Figure 19: DFN8 2 x 2 mm (NB) recommended footprint



4.3 DFN6 1.3 x 1.6 x 0.55 (NA - option 2) package information

Figure 20: DFN6 1.3 x 1.6 x 0.55 package outline

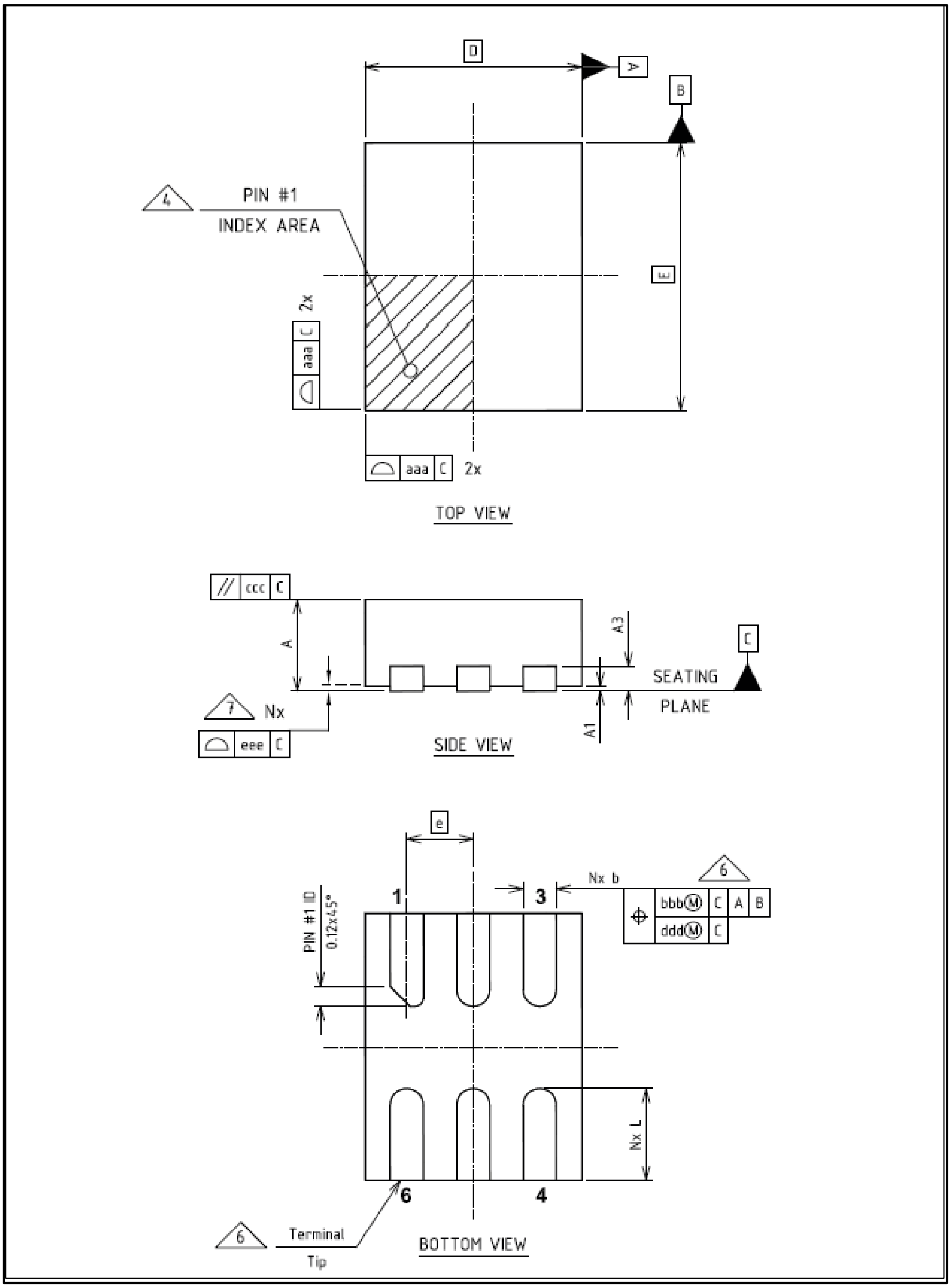
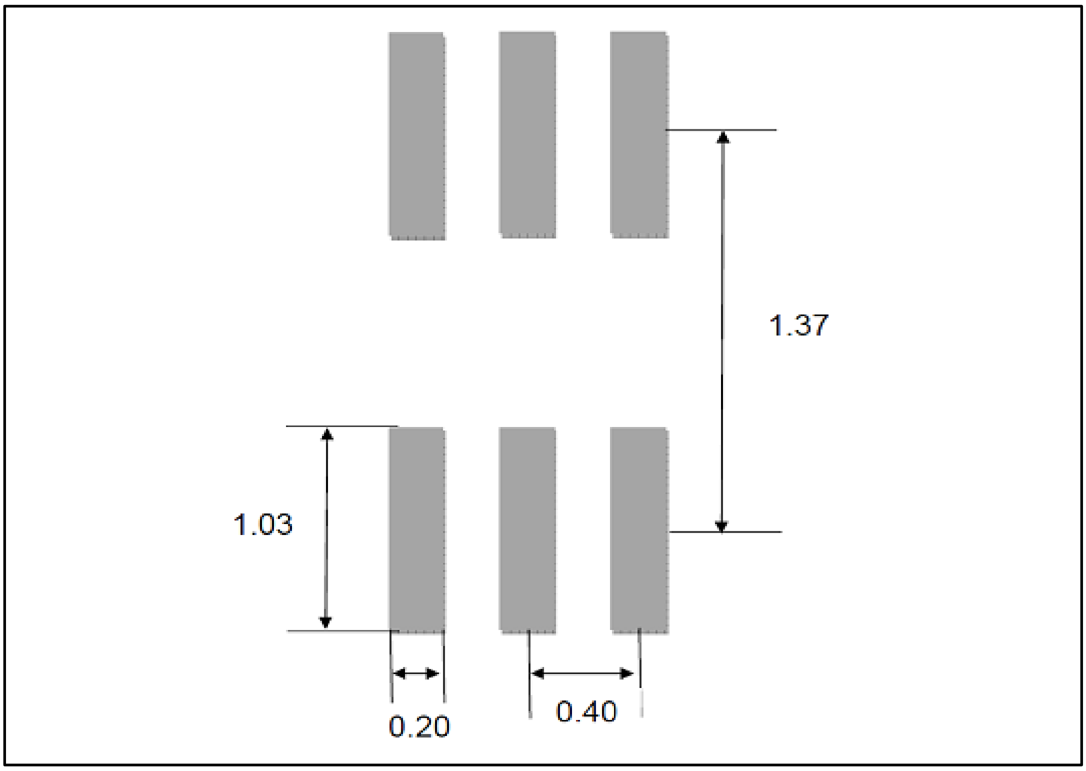


Table 8: DFN6 1.3 x 1.6 x 0.55 mechanical data

Ref.	Dimensions					
	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A	0.50	0.55	0.60	0.020	0.022	0.024
A1	0.00	0.02	0.05	0.000	0.001	0.002
A3		0.15			0.006	
B	0.15	0.20	0.25	0.006	0.008	0.010
D		1.30			0.051	
E		1.60			0.063	
e		0.40			0.016	
L	0.453	0.553	0.653	0.018	0.022	0.026
N		6			0.236	
aaa		0.05			0.002	
bbb		0.07			0.003	
ccc		0.10			0.004	
ddd		0.05			0.002	
eee		0.08			0.003	

Figure 21: DFN6 1.3 x 1.6 x 0.55 recommended footprint



4.4 MiniSO8 package information

Figure 22: MiniSO8 package outline

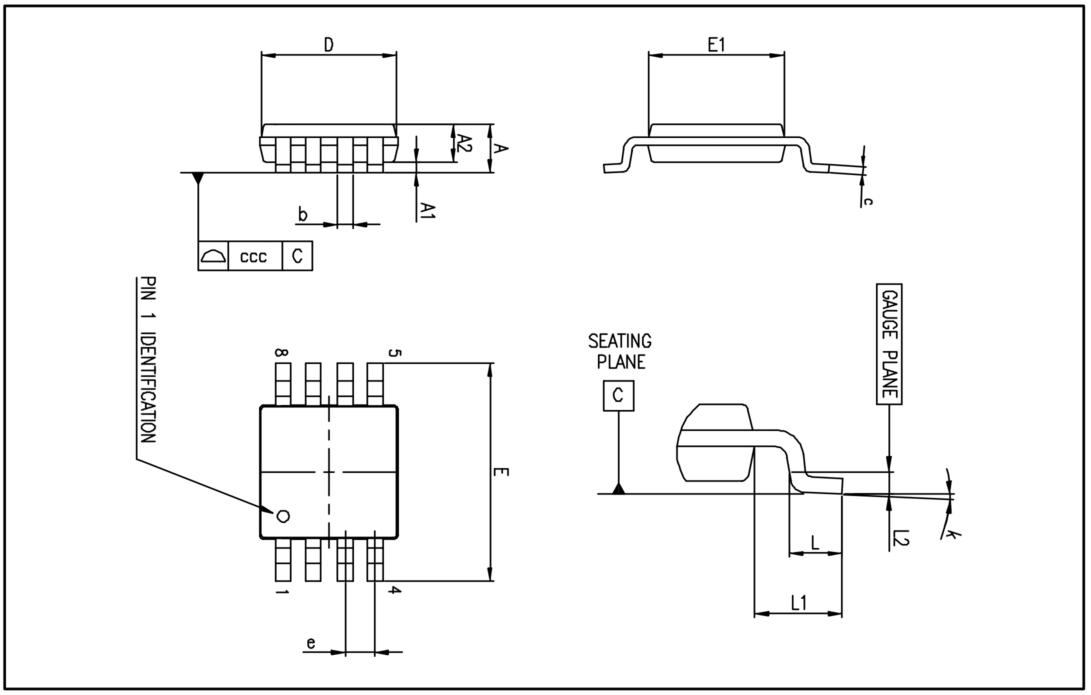


Table 9: MiniSO8 mechanical data

Ref.	Dimensions					
	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.1			0.043
A1	0		0.15	0		0.006
A2	0.75	0.85	0.95	0.030	0.033	0.037
b	0.22		0.40	0.009		0.016
c	0.08		0.23	0.003		0.009
D	2.80	3.00	3.20	0.11	0.118	0.126
E	4.65	4.90	5.15	0.183	0.193	0.203
E1	2.80	3.00	3.10	0.11	0.118	0.122
e		0.65			0.026	
L	0.40	0.60	0.80	0.016	0.024	0.031
L1		0.95			0.037	
L2		0.25			0.010	
k	0°		8°	0°		8°
ccc			0.10			0.004

4.5 SO8 package information

Figure 23: SO8 package outline

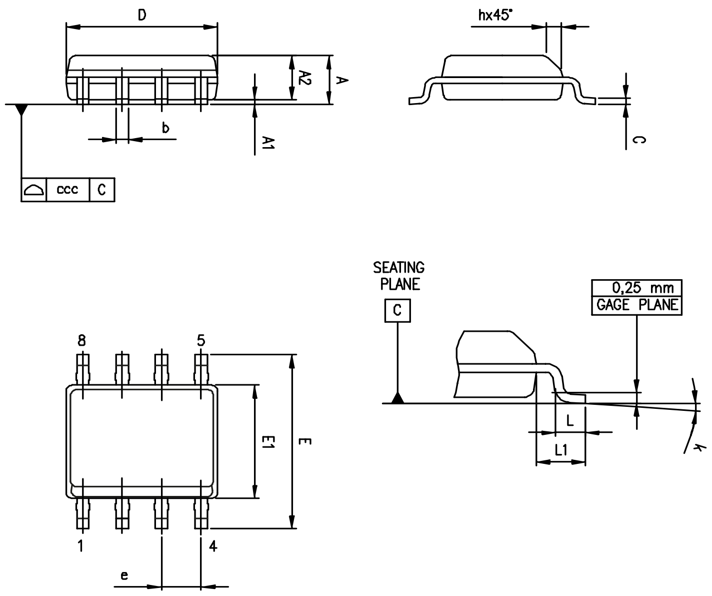


Table 10: SO8 mechanical data

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	1°		8°	1°		8°
ccc			0.10			0.004

4.6 SO14 package information

Figure 24: SO14 package outline

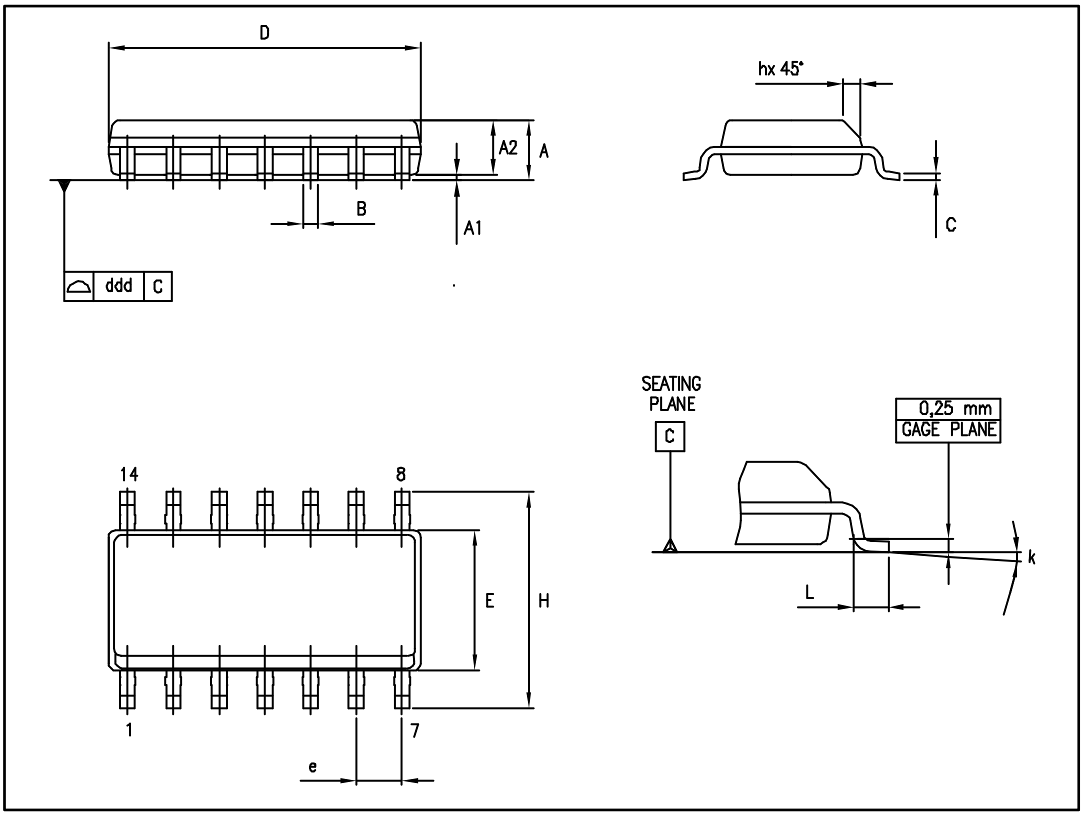


Table 11: SO14 mechanical data

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

4.7 TSSOP14 package information

Figure 25: TSSOP14 package outline

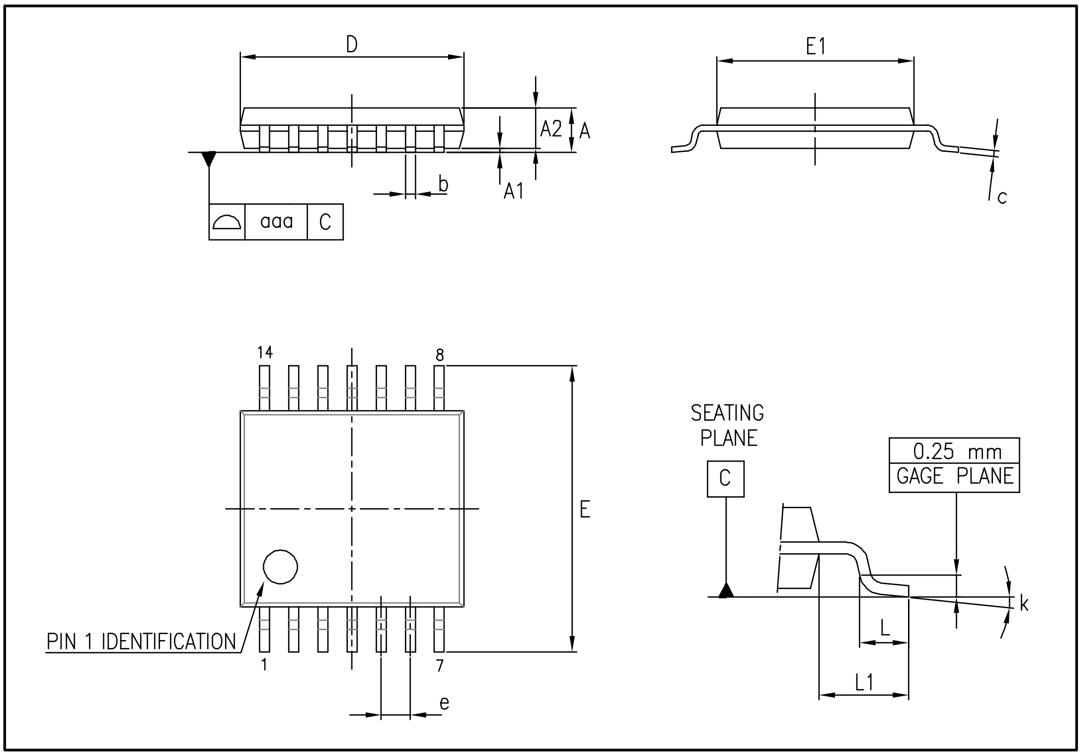


Table 12: TSSOP14 mechanical data

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

5 Ordering information

Table 13: Order codes

Order code	Temperature range	Package	Packing	Marking
TSV991ILT	-40 °C to 125 °C	SOT23-5	Tape and reel	K130
TSV991AILT				K129
TSV991IQ2T		DFN8 2x2		K1F
TSV991AIQ2T				K1E
TSV991AIQ1T		DFN6 1.3x1.6x0.55		K5
TSV992IST		MiniSO8		K132
TSV992AIST				K135
TSV992IDT		SO8		V992I
TSV992AIDT				V992AI
TSV994IPT		TSSOP14		V994I
TSV994AIPT				V994AI
TSV994IDT		SO14		V994I
TSV994AIDT				V994AI
TSV991IYLT [(1)]	-40 °C to 125 °C automotive grade	SOT23-5		K149
TSV991AIYLT [(1)]				K150
TSV992IYDT [(1)]		SO8		V992IY
TSV992AIYDT [(1)]				V992AY
TSV992IYST [(1)]		MiniSO8		K149
TSV992AIYST [(1)]				K150
TSV994IYDT [(1)]		SO14		V994IY
TSV994AIYDT [(1)]				V994AY
TSV994IYPT [(1)]		TSSOP14		V994IY
TSV994AIYPT [(1)]				V994AY

Notes:

[(1)]Qualified and characterized according to AEC Q100 and Q003 or equivalent, advanced screening according to AEC Q001 & Q 002 or equivalent.

In the table above, all packages except the SO14 are "moisture sensitivity level 1" as per Jedec J-STD-020-C. SO14 is Jedec level 3.

6 Revision history

Table 14: Document revision history

Date	Revision	Changes
31-Jul-2006	1	Preliminary data release for product under development.
07-Nov-2006	2	Final version of datasheet.
12-Dec-2006	3	Noise and distortion figures added.
07-Jun-2007	4	ESD tolerance modified for SO14, CDM in *Table 1: "Absolute maximum ratings (AMR)"*. Automotive grade commercial products added in *Table 13: "Order codes"*. Note about SO14 added in *Table 13: "Order codes"*. Limits in temperature added in *Section 2: "Electrical characteristics"*.
11-Feb-2008	5	Corrected MiniSO8 package information. Corrected footnote for automotive grade order codes in order code table. Improved presentation of package information.
25-May-2009	6	Added input current information in table *Table 1: "Absolute maximum ratings (AMR)"*. Added *Section 3: "Application information"*. Updated all packages in *Section 4: "Package information"* . Added new order codes: TSV991IYLT, TSV991AIYLT, TSV992IYST, TSV992AIYST, TSV994IYPT, TSV994AIYPT in *Table 13: "Order codes"*.
19-Oct-2009	7	Added A versions of devices in title on cover page. Added parameters for full temperature range in *Table 3*, *Table 4*, and *Table 5*. Removed gain margin and phase margin parameters in *Table 3*, *Table 4*, and *Table 5*. These parameters have been replaced by the gain parameter (minimum gain for stability). Added *Figure 14* and *Figure 16*.
14-Jan-2010	8	Added parameters for full temperature range in *Table 3*, *Table 4*, and *Table 5*. Modified note relative to automotive grade in *Table 13: "Order codes"*.
22-Oct-2012	9	Document status changed to production data. Modified gain value in *Features* and *Description*. Added DFN8 2x2 pin connection diagram. *Table 1: "Absolute maximum ratings (AMR)"*: added package DFN8 2x2 to rows R_{thja} and ESD. *Table 3*, *Table 4*, and *Table 5*: replaced “DV_{io}” with $\Delta V_{io}/\Delta T$; modified “Gain” and “THD+N” conditions and typical values. *Figure 7* and *Figure 8*: added arrows indicating “Gain” and ‘Phase”.

Date	Revision	Changes
22-Oct-2012	9 cont'd	*Figure 11* and *Figure 12*: updated. Added *Figure 18: "DFN8 2 x 2 mm (NB) package outline"* and *Figure 19: "DFN8 2 x 2 mm (NB) recommended footprint"*. *Table 13: "Order codes"*: updated automotive grade qualification and added order code of DFN8 package.
10-Mar-2014	10	*Table 13: "Order codes"*: added new commercial product TSV991AIQ2T; corrected "Marking" error for TSV991IQ2T from K1E to K1F.
12-Jun-2015	11	Added DFN6 1.3 x 1.6 x 0.55 package for new order code TSV991AIQ1T. Updated "L" dimension of *Section 4.2: "DFN8 2 x 2 (NB) package information"* Updated min "k" value of *Section 4.5: "SO8 package information"*