

TSV991, TSV992, TSV994 TSV991A, TSV992A, TSV994A

Datasheet

High bandwidth (20 MHz for gain ≥ 4) micro-power (820 µA) rail-to-rail 5 V op amps

TSV991 TSV992 TSV994 TSV994 TSV994 TSV994

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

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.

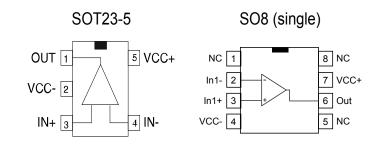
Maturity status link TSV991, TSV992, TSV994, TSV991A, TSV992A, TSV994A

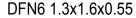
Related products							
See TSV771, TSV772	For 20 MHz unity-gain stable amplifiers						
See TSV911, TSV912, TSV914, TSV911A, TSV912A, TSV914A	For 8 MHz unity-gain stable amplifiers						

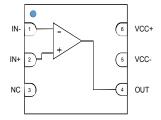


Package pin connections

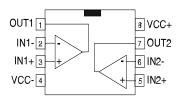
Figure 1. Pin connection (top view)

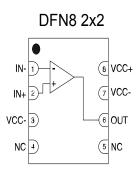




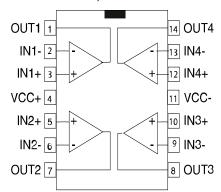


MiniSO8, SO8, DFN8 2x2





SO14, TSSOP14



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Absolute maximum ratings and operating conditions

Table 1. Absolute maximum ratings (AMR)

Symbol	Parameter		Value	Unit
V _{CC}	Supply voltage (1)		6	
V _{id}	Differential input voltage (2)		±V _{CC}	V
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	80
Tj	Maximum junction temperature		150	°C
		DFN8 2x2	57	
		DFN6 1.3x1.6x0.55	230	
_		SOT23-5	250	
R _{thja}	Thermal resistance junction to ambient (5) (6)	SO8	125	°C/W
		MiniSO8	190	
		SO14	103	
		TSSOP14	100	
		SOT23-5	81	
		SO8	40	
R_{thjc}	Thermal resistance junction to case	MiniSO8	39	
		SO14	31	
		TSSOP14	32	
	HBM: human body model (7)		5	kV
	MM: machine model (8)		400	
ESD		SOT23-5, SO8, MiniSO8, DFN8 2x2	1500	V
	CDM: charged device model (9)	DFN6 1.3x1.6x0.55	1500	·
		TSSOP14	750	
		SO14	500	
	Latch-up immunity		200	mA

- 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. Rth are typical values.
- 7. Human body model: 100 pF discharged through a 1.5 k Ω 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 $< 5 \Omega$), 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.

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Absolute maximum ratings and operating conditions

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	V
T _{op}	Operating free air temperature range	-40 to 125	°C

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3 Electrical characteristics

Note:

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

Table 3. Electrical characteristics at $V_{CC+} = 2.5 \text{ V}$, $V_{CC-} = 0 \text{ V}$, $V_{icm} = V_{CC}/2$, with R_L connected to $V_{CC}/2$, full temperature range (unless otherwise specified)

Symbol	Parameter	Conditions	Min.	Тур.	Max.	Unit
		DC performance				
	Offset voltage, TSV99x	T _{op} = 25 °C		0.1	4.5	
V_{io}	Oliset voltage, 13v39x	$T_{min} < T_{op} < T_{max}$			7.5	mV
V 10	Offset voltage, TSV99xA	T _{op} = 25 °C			1.5	1110
	Oliset Voltage, 13 V 33 AA	$T_{min} < T_{op} < T_{max}$			3	
$\Delta V_{io}/\Delta T$	Input offset voltage drift			2		μV/°C
ı.	Input offset current, V _{out} = V _{CC} /2	T _{op} = 25 °C		1	10	
l _{io}	(1)	$T_{min} < T_{op} < T_{max}$			100	
	Input bias current, V _{out} = V _{CC} /2	T _{op} = 25 °C		1	10	pА
I _{ib}	(1)	T _{min} < T _{op} < T _{max}			100	-
OME	Common mode rejection ratio,	0 V to 2.5 V, V _{out} = 1.25 V, T _{op} = 25 °C	58	75		
CMR	$20 \log (\Delta V_{ic}/\Delta V_{io})$	T _{min} < T _{op} < T _{max}	53			
		$R_L = 10 \text{ k}\Omega, V_{out} = 0.5 \text{ V to 2 V},$		00		dB
A_{vd}	Large signal voltage gain	T _{op} = 25 °C	80	89		
		T _{min} < T _{op} < T _{max}	75			-
., .,		$R_L = 10 \text{ k}\Omega, T_{min} < T_{op} < T_{max}$		15	40	
V _{CC} - V _{OH}	High-level output voltage	$R_L = 600 \Omega$, $T_{min} < T_{op} < T_{max}$		45	150	
\ /		$R_L = 10 \text{ k}\Omega, T_{\text{min}} < T_{\text{op}} < T_{\text{max}}$		15	40	mV
V_{OL}	Low-level output voltage	$R_L = 600 \Omega$, $T_{min} < T_{op} < T_{max}$		45	150	
		V _o = 2.5 V, T _{op} = 25 °C	18	32		
	sink	T _{min} < T _{op} < T _{max}	16			
l _{out}		V _o = 0 V, T _{op} = 25 °C	18	35		mA
	Isource	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			ı	ı
GBP	Gain bandwidth product	$R_L = 2 k\Omega$, $C_L = 100 pF$, $f = 100 kHz$, $T_{op} = 25 °C$		20		MHz
Gain	Minimum gain for stability	Phase margin = 45 °, R_f = 10 k Ω , R_L = 2 k Ω , C_L = 100 pF, T_{op} = 25 °C, positive gain configuration		4		V/V
Gain	Minimum gain for stability	Phase margin = 45 °, R_f = 10 k Ω , R_L = 2 k Ω , C_L = 100 pF, T_{op} = 25 °C, negative gain configuration		-3		V/V
SR	Slew rate	$R_L = 2 k\Omega$, $C_L = 100 pF$, $T_{op} = 25 °C$		10		V/µs

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Symbol	Parameter	Conditions	Min.	Тур.	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, $V_{icm} = V_{CC}/2$, $V_{out} = 2$ V_{pp} , $T_{op} = 25$ °C		0.0025		%

^{1.} Guaranteed by design.

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Table 4. Electrical characteristics at $V_{CC+} = 3.3 \text{ V}$, $V_{CC-} = 0 \text{ V}$, $V_{icm} = V_{CC}/2$, with R_L connected to $V_{CC}/2$, full temperature range (unless otherwise specified)

Symbol	Parameter	Conditions	Min.	Тур.	Max.	Unit
		DC performance				
	05 4 4 7040	T _{op} = 25 °C		0.1	4.5	
.,	Offset voltage, TSV99x	$T_{min} < T_{op} < T_{max}$			7.5	
V_{io}	0.5. 1 11 70,400 4	T _{op} = 25 °C			1.5	mV
	Offset voltage, TSV99xA	$T_{min} < T_{op} < T_{max}$			3	
$\Delta V_{io}/\Delta T$	Input offset voltage drift			2		μV/°C
	Input offset current, V _{out} = V _{CC} /2	T _{op} = 25 °C		1	10	
l _{io}	(1)	$T_{min} < T_{op} < T_{max}$			100	- A
L	Input bias current, V _{out} = V _{CC} /2	T _{op} = 25 °C		1	10	pA
l _{ib}	(1)	$T_{min} < T_{op} < T_{max}$			100	
CMD	Common mode rejection ratio,	0 V to 3.3 V, V _{out} = 1.65 V, T _{op} = 25 °C	60	78		
CMR	$20 \log (\Delta V_{ic}/\Delta V_{io})$	$T_{min} < T_{op} < T_{max}$	55			
		$R_L = 10 \text{ k}\Omega$, $V_{out} = 0.5 \text{ V to } 2.8 \text{ V}$,	90	90		dB
A_{vd}	Large signal voltage gain	T _{op} = 25 °C	80	89		
		$T_{min} < T_{op} < T_{max}$	75			
/ \/	High-level output voltage	$R_L = 10 \text{ k}\Omega$, $T_{min} < T_{op} < T_{max}$		15	40	mV
/ _{CC} - V _{OH}		$R_L = 600 \Omega$, $T_{min} < T_{op} < T_{max}$		45	150	
	Low-level output voltage	$R_L = 10 \text{ k}\Omega$, $T_{min} < T_{op} < T_{max}$		15	40	
V_{OL}	Low-level output voltage	$R_L = 600 \Omega$, $T_{min} < T_{op} < T_{max}$		45	150	
	I _{sink}	V _o = 3.3 V, T _{op} = 25 °C	18	32		
1		$T_{min} < T_{op} < T_{max}$	16			
l _{out}		V _o = 0 V, T _{op} = 25 °C	18	35		mA
	Isource	$T_{min} < T_{op} < T_{max}$	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 k Ω , C_L = 100 pF, f = 100 kHz, T_{op} = 25 °C		20		MHz
Gain	Minimum gain for stability	Phase margin = 45 °, R_f = 10 k Ω , R_L = 2 k Ω , C_L = 100 pF, T_{op} = 25 °C, positive gain configuration		4		V/V
Gain	Withinfurn gain for Stability	Phase margin = 45 °, R_f = 10 k Ω , R_L = 2 k Ω , C_L = 100 pF, T_{op} = 25 °C, negative gain configuration		-3		V/V
SR	Slew rate	R_L = 2 k Ω , C_L = 100 pF, f = 100 kHz, T_{op} = 25 °C		10		V/µs
e _n	Equivalent input noise voltage	f = 10 kHz, T _{op} = 25 °C		21		nV/√H
THD+N	Total harmonic distortion	G = -3, f = 1 kHz, R_L = 2 k Ω , Bw = 22 kHz, V_{icm} = $V_{CC}/2$, V_{out} = 2.8 V_{pp} , V_{op} = 25 °C		0.0018		%

^{1.} Guaranteed by design.

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Table 5. Electrical characteristics at $V_{CC+} = 5 \text{ V}$, $V_{CC-} = 0 \text{ V}$, $V_{icm} = V_{CC}/2$, with R_L connected to $V_{CC}/2$, full temperature range (unless otherwise specified)

Symbol	Parameter	Conditions	Min.	Тур.	Max.	Unit
		DC performance				
		T _{op} = 25 °C		0.1	4.5	
.,	Offset voltage, TSV99x	$T_{min} < T_{op} < T_{max}$			7.5	
V_{io}		T _{op} = 25 °C			1.5	mV
	Offset voltage, TSV99xA	$T_{min} < T_{op} < T_{max}$			3	
$\Delta V_{io}/\Delta T$	Input offset voltage drift			2		μV/°C
	Input offset current, V _{out} = V _{CC} /2	T _{op} = 25 °C		1	10	
l _{io}	(1)	$T_{min} < T_{op} < T_{max}$			100	
	Input bias current, V _{out} = V _{CC} /2	T _{op} = 25 °C		1	10	pA
l _{ib}	(1)	$T_{min} < T_{op} < T_{max}$			100	
		0 V to 5 V, V _{out} = 2.5 V,				
CMR	Common mode rejection ratio, 20 log $(\Delta V_{ic}/\Delta V_{io})$	T _{op} = 25 °C	62	82		
	20 10g (AV ₁₀ , AV ₁₀)	$T_{min} < T_{op} < T_{max}$	57			
SVR	Supply voltage rejection ratio, 20 $\log (\Delta V_{cc}/\Delta V_{io})$	V _{CC} = 2.5 V to 5 V	70	86		dB
		$R_L = 10 \text{ k}\Omega, V_{\text{out}} = 0.5 \text{ V to } 4.5 \text{ V},$	80	91		
A_{vd}	Large signal voltage gain	T _{op} = 25 °C				
		$T_{min} < T_{op} < T_{max}$	75			
′cc - V _{он}	High-level output voltage	$R_L = 10 \text{ k}\Omega, T_{\text{min}} < T_{\text{op}} < T_{\text{max}}$		15	40	
	Tilgh-level output voltage	$R_L = 600 \Omega$, $T_{min} < T_{op} < T_{max}$		45	150	mV
V_{OL}	ow-level output voltage	$R_L = 10 \text{ k}\Omega, T_{\text{min}} < T_{\text{op}} < T_{\text{max}}$		15	40	
		$R_L = 600 \Omega$, $T_{min} < T_{op} < T_{max}$		45	150	
	Isink	V _o = 5 V, T _{op} = 25 °C	18	32		
l _{out}	SHIK	$T_{min} < T_{op} < T_{max}$	16			
·out	I _{source}	$V_0 = 0 \text{ V}, T_{op} = 25 ^{\circ}\text{C}$	18	35		mA
	Source	$T_{min} < T_{op} < T_{max}$	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	$R_L = 2 \text{ k}\Omega$, $C_L = 100 \text{ pF}$, $f = 100 \text{ kHz}$, $T_{op} = 25 ^{\circ}\text{C}$		20		MHz
	Malana	Phase margin = 45 °, R_f = 10 k Ω , R_L = 2 k Ω , C_L = 100 pF, T_{op} = 25 °C, positive gain configuration		4		10.
Gain Minimum gain for stability		Phase margin = 45 °, R_f = 10 k Ω , R_L = 2 k Ω , C_L = 100 pF, T_{op} =25 °C, negative gain configuration		-3		V/V
SR	Slew rate	$R_L = 2 \text{ k}\Omega$, $C_L = 100 \text{ pF}$, $f = 100 \text{ kHz}$, $T_{op} = 25 \text{ °C}$		10		V/µs
e _n	Equivalent input noise voltage	f = 10 kHz, T _{op} = 25 °C		21		nV/√H

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Electrical characteristics

Symbol	Parameter	Conditions	Min.	Тур.	Max.	Unit
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		%

^{1.} Guaranteed by design.

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Electrical characteristic curves

Figure 2. Input offset voltage distribution at T = 25 °C 140 Vcc=5VVicm=2.5 V 120 Ta mb=25°C 100 Quantity of parts 80 60 40 20 -3 0 -1 Input offs et Voltage (mV)

Figure 3. Input offset voltage distribution at T = 125 °C

40

Vcc=5V
Vicm=2.5V
Tamb=125°C

Value offset Voltage (mV)

Figure 4. Supply current vs. input common-mode voltage at $V_{CC} = 2.5 \text{ V}$

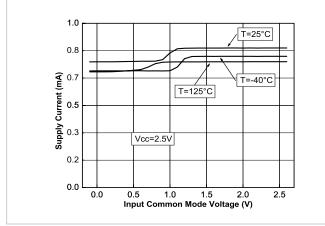


Figure 5. Supply current vs. input common-mode voltage at V_{CC} = 5 V

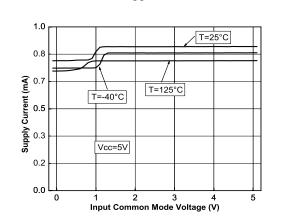


Figure 6. Output current vs. output voltage at V_{CC} = 2.5 V

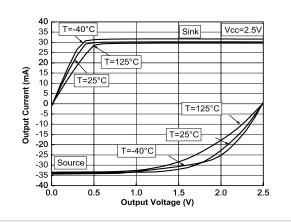
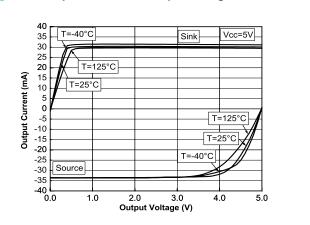


Figure 7. Output current vs. output voltage at $V_{CC} = 5 \text{ V}$



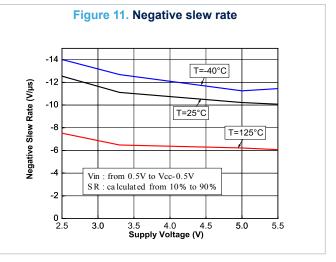
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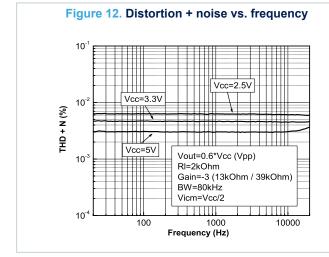


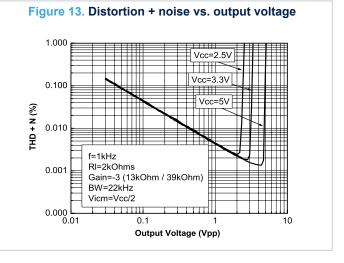
Figure 8. Voltage gain and phase vs. frequency at $V_{CC} = 5$ V and V_{icm} = 0.5 V 40 160 Gain 30 120 Phase 20 80 40 10 Gain (dB) 0 0 -10 -40 -80 -20 Vcc=5V, Vicm=0.5V CI=100pF, RI=2KOhm, VrI=Vcc/2 -30 120 Tamb=25°C -160 10⁵ 10⁶ 10⁷ Frequency (Hz)

Figure 9. Voltage gain and phase vs. frequency at $V_{CC} = 5$ V and V_{icm} = 2.5 V 40 160 Gain Phase 30 120 20 80 10 Gain (dB) 0 -10 -40 -20 -80 Vcc=5V, Vicm=2.5V Cl=100pF, Rl=2KOhm, Vrl=Vcc/2 Tamb=25°C -30 -120 10 107 Frequency (Hz)

Figure 10. Positive slew rate 14 12 T=25°C Positive Slew Rate (V/µs) T=125°C T=-40°C Vin: from 0.5V to Vcc-0.5V $S\,R$: calculated from 10% to 90% 2 0 L 2.5 3.0 4.0 5.0 5.5 Supply Voltage (V)





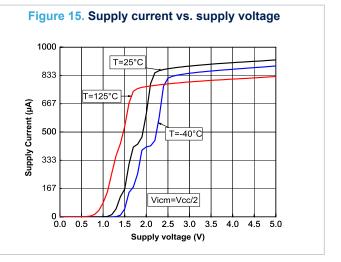


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Figure 14. Noise vs. frequency

(ZHANU)



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Application information

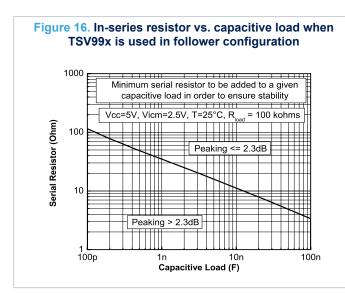
5.1 Driving resistive and capacitive loads

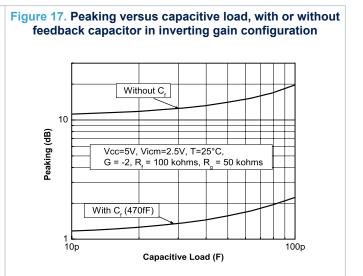
These products are low-voltage, low-power operational amplifiers optimized to drive rather large resistive loads above $2 \text{ k}\Omega$.

The 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 16 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 17, the feedback capacitor drastically reduces the peaking versus capacitive load (inverting gain configuration, gain = -2).





5.2 PCB layouts

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

5.3 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 performance 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.

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6 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.

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6.1 SOT23-5 package information

Figure 18. SOT23-5 package outline

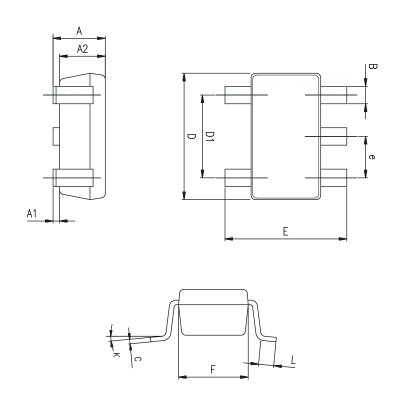


Table 6. SOT23-5 mechanical data

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

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6.2 DFN8 2 x 2 package information

SEATING PLANE

C

D

D

PIN#1 ID

R

BOTTOM VIEW

Figure 19. DFN8 2 x 2 package outline

Table 7. DFN8 2 x 2 mechanical data

	Dimensions							
Ref.	Millimeters			Inches				
	Min.	Тур.	Max.	Min.	Тур.	Max.		
Α	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		
е		0.50			0.020			
L			0.425			0.017		
ddd			0.08			0.003		

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0.45mm 0.75mm 2.80mm

Figure 20. DFN8 2 x 2 recommended footprint

Note: The exposed pad of the DFN8 2x2 package is not internally connected. It can be set to V_{CC}^- or left floating.

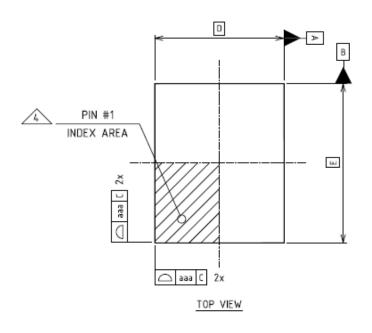
0.50mm

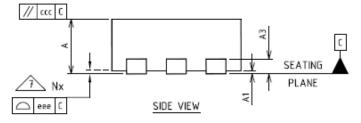
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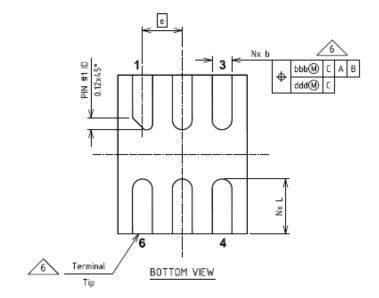


6.3 DFN6 1.3 x 1.6 x 0.55 package information

Figure 21. DFN6 1.3 x 1.6 x 0.55 package outline







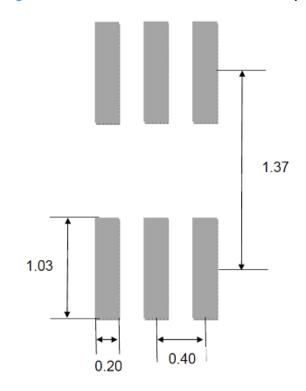
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Table 8. DFN6 1.3 x 1.6 x 0.55 mechanical data

		Dimensions							
Ref.		Millimeters		Inches					
	Min.	Тур.	Max.	Min.	Тур.	Max.			
Α	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				
В	0.15	0.20	0.25	0.006	0.008	0.010			
D		1.30			0.051				
E		1.60			0.063				
е		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 22. DFN6 1.3 x 1.6 x 0.55 recommended footprint



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6.4 MiniSO8 package information

Figure 23. MiniSO8 package outline

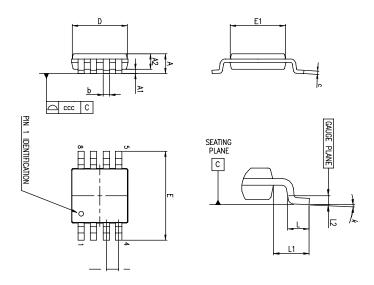


Table 9. MiniSO8 package mechanical data

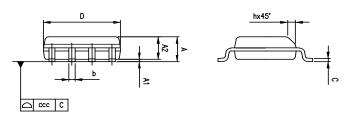
	Dimensions								
Ref.	Millimeters			Inches					
	Min.	Тур.	Max.	Min.	Тур.	Max.			
Α			1.1			0.043			
A1	0		0.15	0		0.0006			
A2	0.75	0.85	0.95	0.030	0.033	0.037			
b	0.22		0.40	0.009		0.016			
С	0.08		0.23	0.003		0.009			
D	2.80	3.00	3.20	0.11	0.118	0.126			
E	4.65	4.90	5.15	0.183	0.193	0.203			
E1	2.80	3.00	3.10	0.11	0.118	0.122			
е		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			

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6.5 SO8 package information

Figure 24. SO8 package outline



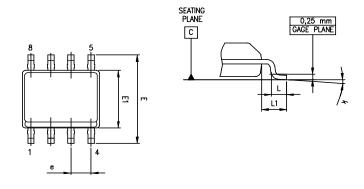


Table 10. SO8 package mechanical data

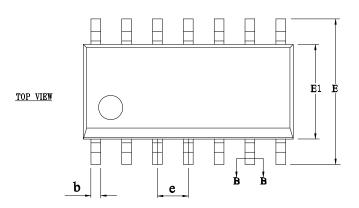
	Dimensions						
Ref.		Millimeters			Inches		
	Min.	Тур.	Max.	Min.	Тур.	Max.	
А			1.75			0.069	
A1	0.10		0.25	0.004		0.010	
A2	1.25			0.049			
b	0.28		0.48	0.011		0.019	
С	0.17		0.23	0.007		0.010	
D	4.80	4.90	5.00	0.189	0.193	0.197	
Е	5.80	6.00	6.20	0.228	0.236	0.244	
E1	3.80	3.90	4.00	0.150	0.154	0.157	
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	

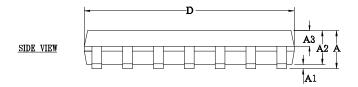
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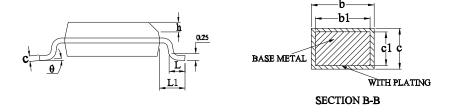


6.6 SO-14 package information

Figure 25. SO-14 package outline







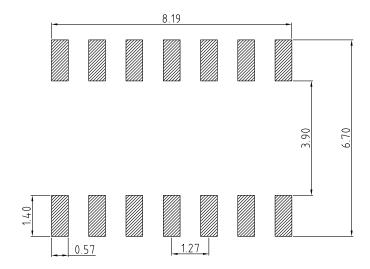
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Table 11. SO-14 package mechanical data

	Dimensions						
Dim.	Millimeters			Inches			
	Min.	Тур.	Max.	Min.	Тур.	Max.	
А			1.75			0.069	
A1	0.10		0.225	0.004		0.009	
A2	1.30	1.40	1.50	0.051	0.055	0.059	
A3	0.60	0.65	0.70	0.024	0.026	0.028	
b	0.39		0.47	0.015		0.019	
b1	0.38	0.41	0.44	0.015	0.016	0.017	
С	0.20		0.24	0.008		0.009	
c1	0.19	0.20	0.21	0.0075	0.0079	0.0083	
D	8.55	8.65	8.75	0.337	0.341	0.344	
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 BSC			0.050 BSC		
h	0.25		0.50	0.010		0.020	
L	0.50		0.80	0.020		0.031	
L1		1.05 REF			0.041 REF		
θ	8° (max)						

Figure 26. SO-14 recommended footprint

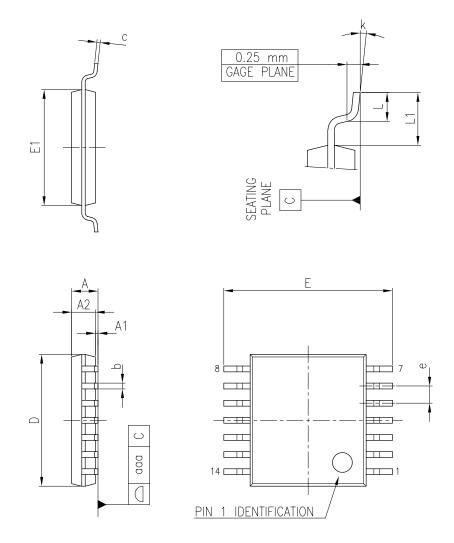


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6.7 TSSOP-14 package information

Figure 27. TSSOP-14 package outline



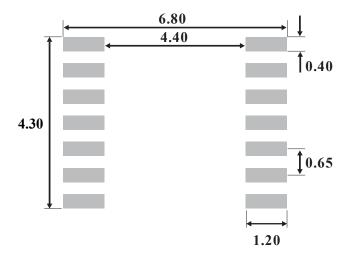
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Table 12.	TSSOP-14	nackage	mechanical	data

	Dimension						
Dim.		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	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	0.177	
е		0.65 BSC			0.25 BSC		
L	0.45	0.60	0.75	0.018	0.024	0.030	
L1		1.00			0.039		
k	8° (max)						
aaa			0.10			0.004	

Figure 28. TSSOP-14 recommended footprint



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Ordering information

Table 13. Order code

TSV991ILT TSV991AILT TSV991AIQT TSV991AQT TSV991AQT TSV991AQT TSV991AQT TSV991AQT TSV992AIGT TSV994AIGT TSV994AIGT TSV994AIGT TSV994AIGT TSV994AIGT TSV994IVT TSV991IYLT TSV991IYLT TSV991IYLT TSV991IYLT TSV991IYDT TSV991IYDT TSV992AIYDT TSV992AIYGT TSV992IYST TSV992AIYGT TSV992AIYGT TSV994AIYGT TSV994AIYG	Order code	Temperature range	Package	Packing	Marking
TSV991ALT TSV991AQT TSV991AQT TSV991AQT TSV991AQT TSV991AQT TSV991AQT TSV991AQT TSV992AQT TSV992AQT TSV992AQT TSV992AQT TSV992AQT TSV994AQT TSV991AYQT TSV991AYQT TSV991AYQT TSV991AYQT TSV992AQT TSV992AQT TSV991AYQT TSV992AQT TSV992AQT TSV992AQT TSV992AQT TSV992AQT TSV992AQT TSV992AQT TSV994AQT TSV	TSV991ILT		SOT22 5		K130
TSV991AIQ2T TSV991AIQ1T TSV992AIST TSV992AIST TSV992AIST TSV992AIDT TSV992AIDT TSV994AIDT TSV994AIDT TSV991AIVDT TSV992AIYDT TSV992AIYDT TSV992AIYDT TSV992AIYDT TSV992AIYDT TSV992AIYDT TSV994AIYDT TSSOP14	TSV991AILT		30123-3		K129
TSV991AIQ2T TSV991AIQ1T TSV991AIQ1T TSV992AIST TSV992AIST TSV992AIST TSV992AIST TSV992AIST TSV992AIDT TSV994AIDT TSV994AIDT TSV994AIDT TSV991IYDT TSV991IYDT TSV992AIYDT TSV992AIYDT TSV992AIYDT TSV992AIYDT TSV992AIYDT TSV992AIYDT TSV994IYDT TSSOP14	TSV991IQ2T		DENIG 2v2		K1F
TSV992IST TSV992AIST TSV992IDT TSV992IDT SO8 SO8 SO8 TSV992IDT TSV992IDT TSV994IDT TSV994IDT TSV994IDT TSV994IDT TSV994IDT TSV994IDT TSV994IDT TSV991IYLT TSV991IYLT TSV991IYLT TSV991IYDT TSV991IYDT TSV992AIYDT TSV994IYDT TSSOP14	TSV991AIQ2T		DFINO 2X2		K1E
TSV992AIST TSV992IDT TSV992IDT TSV992IDT SO8 SO8 SO8 TSV992IDT TSV992IDT TSV994AIPT TSV994IPT TSV994IDT TSV994IDT TSV994IDT TSV994IDT TSV991IYLT TSV991IYLT TSV991IYDT TSV991IYDT TSV992AIYDT TSV992AIYDT TSV992AIYDT TSV992AIYDT TSV992AIYDT TSV992AIYDT TSV992AIYDT TSV992AIYDT TSV994IIYDT TSSOP14	TSV991AIQ1T		DFN6 1.3x1.6x0.55		K5
TSV992AIST TSV992IDT TSV992IDT TSV992IDT TSV992IDT TSV992IDT TSV992IDT TSV992IDT TSV994IPT TSSOP14 TSSOP14 TSV994IPT TSV994IPT TSV994IPT TSV994IPT TSV994IPT TSV994IPT TSV991IYLT TSV991IYLT TSV991IYLT TSV991IYDT TSV991IYDT TSV992IYDT TSV992IYDT TSV992IYDT TSV992IYST TSV992IYST TSV992IYST TSV992IYST TSV994IYDT TSV994IYPT TSSOP14	TSV992IST		Missiono	K132	
TSV992IDT TSV992AIDT TSV992IDT TSV992IDT TSV992IDT TSV992IDT TSV992IDT TSV994IPT TSV994IPT TSV994IPT TSV994IDT TSV994IDT TSV994IDT TSV991IYLT TSV991IYLT TSV991IYLT TSV991IYDT TSV991IYDT TSV992IYDT TSV992IYDT TSV992IYDT TSV992IYST TSV992IYST TSV992IYST TSV994IIYDT TSSOP14	TSV992AIST	40 °C to 125 °C	WIIIIISO6		K135
TSV992AIDT TSV992IQ2T DFN8 2x2 K38 V994IPT TSV994IPT TSV994IPT TSV994IPT TSV994IDT SO14 Tape and reel V994I V994AI V994AI TSV991IYLT SOT23-5 K150 V991IY TSV991IYDT TSV992IYDT TSV992IYDT TSV992IYDT TSV992IYST automotive grade (1) SO14 TSV994AIYDT TSV994IYPT TSSOP14	TSV992IDT	-40 C to 125 C			V992I
TSV994IPT TSV994IPT TSV994IPT TSV994IPT TSV994IPT TSV994IPT TSV994IPT TSV994IPT TSV994IPT TSV991IYLT TSV991IYLT TSV991IYDT TSV991IYDT TSV992IYDT TSV992IYDT TSV992IYST TSV992IYST TSV992IYST TSV994IYDT TSV994IYPT TSSOP14 TSSOP14	TSV992AIDT				V992AI
TSV994AIPT	TSV992IQ2T	_	DFN8 2x2		K38
TSV994AIPT TSV994AIDT Tape and reel Tape and reel V994AI V994AI	TSV994IPT			Tape and reel	V994I
TSV994AIDT	TSV994AIPT		1550P14		V994AI
TSV994AIDT V994AI TSV991IYLT SOT23-5 K149 TSV991AIYLT K150 TSV991IYDT V991IY TSV992IYDT TSV992IYDT TSV992IYST TSV992IYST TSV992AIYST TSV994IYDT TSV994IYDT TSV994IYDT TSV994AIYDT TSV994AIYDT TSV994AIYDT TSV994IYPT TSV994IYPT TSSOP14 TSV994IYDT TSSOP14	TSV994IDT		2014		V994I
TSV991AIYLT	TSV994AIDT		5014		V994AI
TSV991AIYLT	TSV991IYLT		COTO2 F	-	K149
TSV991AIYDT	TSV991AIYLT		50123-5		K150
TSV992IYDT	TSV991IYDT			-	V991IY
TSV992IYDT	TSV991AIYDT		200		V991AY
TSV992IYST automotive grade (1) TSV992IYST TSV994IYDT TSV994IYDT TSV994IYPT TSV994IYPT TSSOP14 K149 K149 K149 K150 V994IY V994IY	TSV992IYDT		508		V992IY
TSV992IYST automotive grade (1) TSV992AIYST TSV994IYDT TSV994IYDT TSV994IYPT TSV994IYPT Automotive grade (1) MiniSO8 K149 K149 K150 V994IY V994IY V994IY	TSV992AIYDT	-40 °C to 125 °C			V992AY
TSV992AIYST TSV994IYDT TSV994AIYDT TSV994IYPT TSV994IYPT TSSOP14 K150 V994IY V994IY	TSV992IYST		Minisopo		K149
TSV994AIYDT	TSV992AIYST		Minisos		K150
TSV994AIYDT V994AIY TSV994IYPT TSSOP14 V994AIY	TSV994IYDT		2011		V994IY
TSSOP14	TSV994AIYDT		SO14		V994AIY
	TSV994IYPT		T000544		V994IY
	TSV994AIYPT		TSSOP14		V994AY

Qualified and characterized according to AEC Q100 and Q003 or equivalent, advanced screening according to AEC Q001 & Q 002 or equivalent.

Note: 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.

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Revision history

Table 14. Document revision history

Date	Revision	Changes
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: "DFN8 2 x 2 mm (NB) package information". Updated min "k" value of Section 4.5: "SO8 package information".
27-Nov-2015	12	Table 3, Table 4, and Table 5: modified that R_L = 600 Ω (not 600 $k\Omega$) for the high-level and low-level output voltage parameters. Section 5.2: updated name of package and titles of drawings and table; added note about exposed pad. Section 5.3: updated name of package.
03-Apr-2018	13	Updated cover image and Table 13. Order code.
19-Jun-2019	14	Updated the related product table in cover page.
14-Sep-2022	15	Updated figure on the cover page. Added TSV991IYDT and TSV991AIYDT new order codes in Table 13. Order code.
14-Mar-2023	16	Updated title, figure and related products on the cover page. Added ESD value for DFN6 in Table 1 and new Section 1 Package pin connections.

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