钍地半导体
Tudi Semiconductor

Product Specification

TUDI-TSV991/TSV992/TSV994

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

网址 www.sztdbdt.com

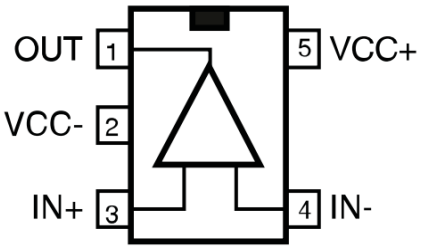
用芯智造·卓越品质

semiconductor device manufacturer

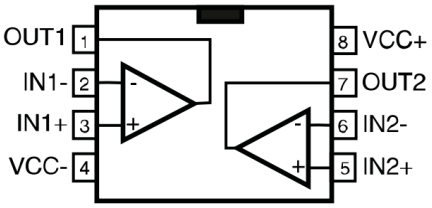
- Design
- research and development
- production
- and sales

Features

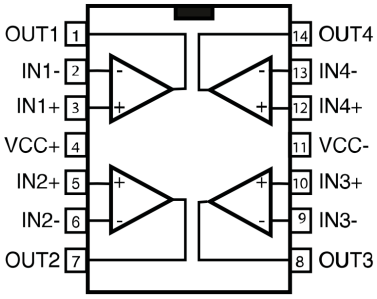
- Low input offset voltage: 1.5 mV max (A grade)
- Rail-to-rail input and output
- Wide bandwidth 20 MHz
- Stable for gain ≥ 4 or ≤ -3
- Low power consumption: 820 µA typ
- High output current: 35 mA
- Operating from 2.5 V to 5.5 V
- Low input bias current, 1 pA typ
- ESD internal protection ≥ 5 kV



SOT23-5



MiniSO8, SO8



SO14, TSSOP14

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 gainbandwidth, 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.

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, with 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 Ω, $T_{min} < T_{op} < T_{max}$		45	150	
V_{OL}	Low-level output voltage	R_L = 10 kΩ, $T_{min} < T_{op} < T_{max}$		15	40	
		R_L = 600 Ω, $T_{min} < T_{op} < T_{max}$		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, with 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	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 Ω, $T_{min} < T_{op} < T_{max}$		45	150	
V_{OL}	Low-level output voltage	R_L = 10 kΩ, $T_{min} < T_{op} < T_{max}$		15	40	
		R_L = 600 Ω, $T_{min} < T_{op} < T_{max}$		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, with 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 V 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 Ω, $T_{min} < T_{op} < T_{max}$		45	150	
V_{OL}	Low-level output voltage	R_L = 10 kΩ, $T_{min} < T_{op} < T_{max}$		15	40	
		R_L = 600 Ω, $T_{min} < T_{op} < T_{max}$		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, 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/√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		%

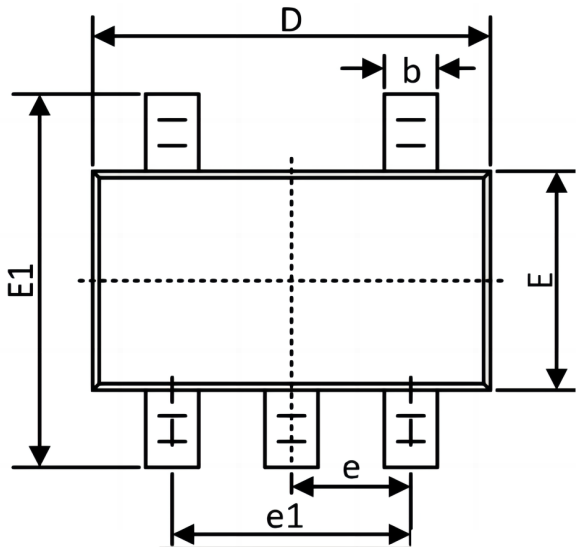
Notes:

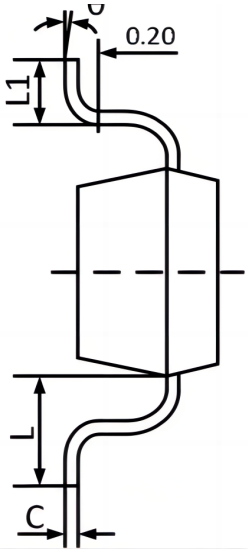
(1)Guaranteed by design

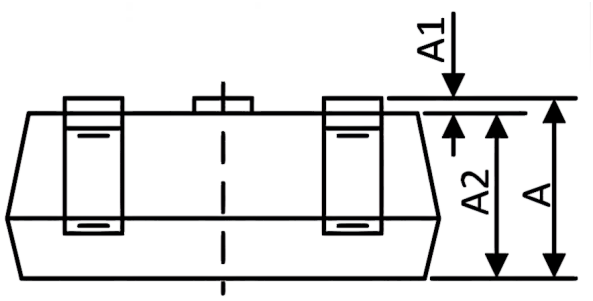
Order information

Order Number	Package	Package Quantity	Marking On The park
TSV991AILT-TUDI	SOT23	Tape,Reel,3000	TSV991AILT
TSV991AIYLT-TUDI	SOT23	Tape,Reel,3000	TSV991AIYLT
TSV991ILT-TUDI	SOT23	Tape,Reel,3000	TSV991ILT
TSV991IYLT-TUDI	SOT23	Tape,Reel,3000	TSV991IYLT
TSV992AIDT-TUDI	SOP8	Tape,Reel,2500	TSV992AIDT
TSV992AIST-TUDI	MSOP8	Tape,Reel,2500	TSV992AIST
TSV992AIYDT-TUDI	SOP8	Tape,Reel,2500	TSV992AIYDT
TSV992IDT-TUDI	SOP8	Tape,Reel,2500	TSV992IDT
TSV992IST-TUDI	MSOP8	Tape,Reel,2500	TSV992IST
TSV992IYDT-TUDI	SOP8	Tape,Reel,2500	TSV992IYDT
TSV994AIDT-TUDI	SOP14	Tape,Reel,2500	TSV994AIDT
TSV994AIPT-TUDI	TSSOP14	Tape,Reel,2500	TSV994AIPT
TSV994AIYDT-TUDI	SOP14	Tape,Reel,2500	TSV994AIYDT
TSV994AIYPT-TUDI	TSSOP14	Tape,Reel,2500	TSV994AIYPT
TSV994IDT-TUDI	SOP14	Tape,Reel,2500	TSV994IDT
TSV994IPT-TUDI	TSSOP14	Tape,Reel,2500	TSV994IPT
TSV994IYPT-TUDI	TSSOP14	Tape,Reel,2500	TSV994IYPT

Package SOT23-5

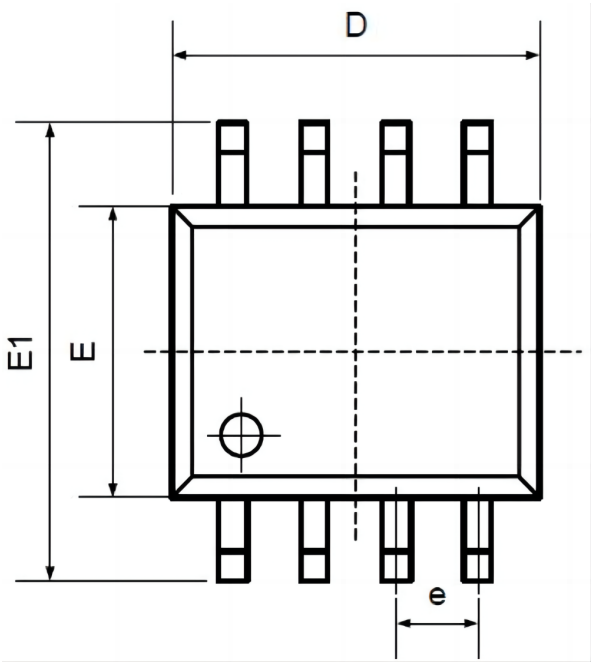


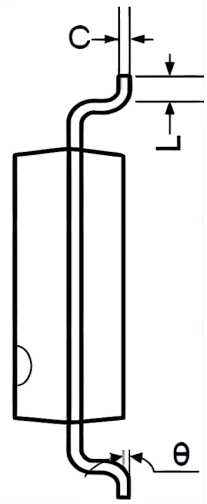


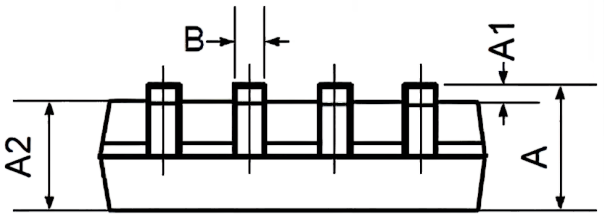


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.400	0.012	0.016
C	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950TYP		0.037TYP	
e1	1.800	2.000	0.071	0.079
L	0.700REF		0.028REF	
L1	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°

Package SOP8

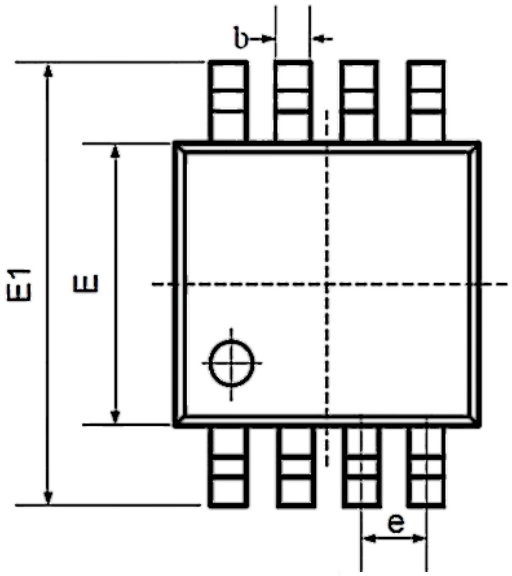


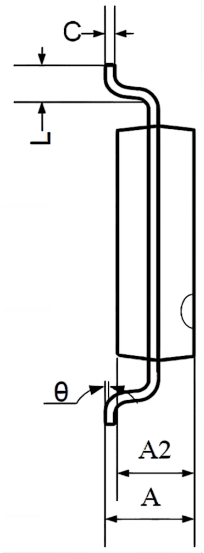


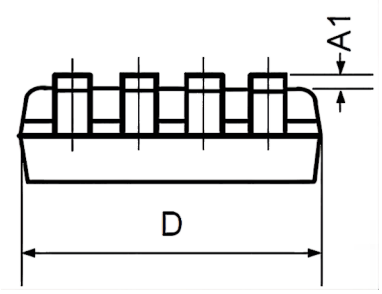


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
B	0.330	0.510	0.013	0.020
C	0.190	0.250	0.007	0.010
D	4.780	5.000	0.188	0.197
E	3.800	4.000	0.150	0.157
E1	5.800	6.300	0.228	0.248
e	1.270TYP		0.050TYP	
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°

Package MSOP8

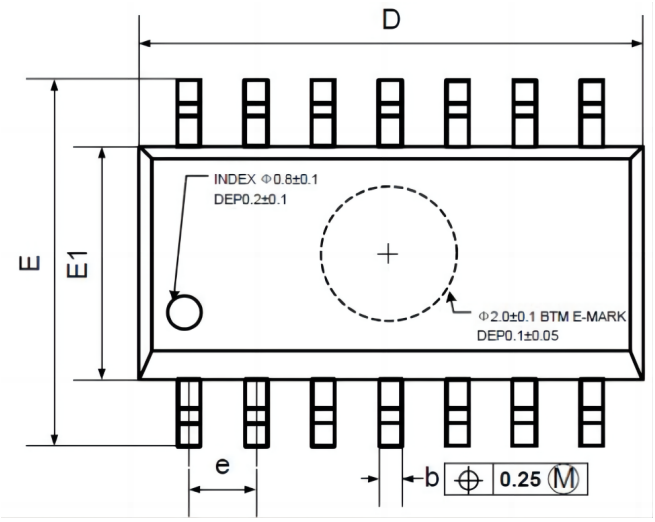


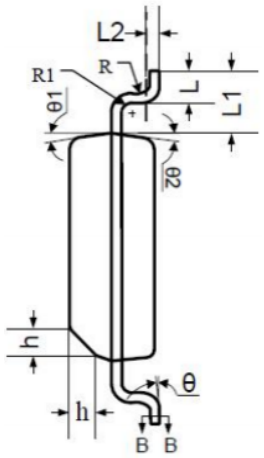


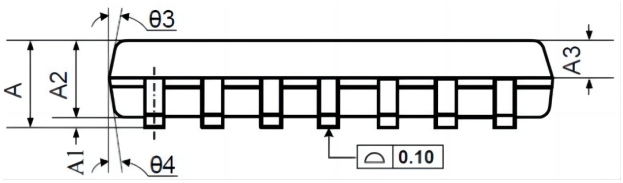


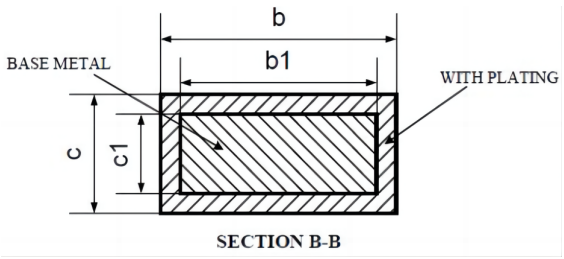
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0.800	1.200	0.031	0.047
A1	0.000	0.200	0.000	0.008
A2	0.760	0.970	0.030	0.038
b	0.30 TYP		0.012 TYP	
C	0.15 TYP		0.006 TYP	
D	2.900	3.100	0.114	0.122
e	0.65 TYP		0.026 TYP	
E	2.900	3.100	0.114	0.122
E1	4.700	5.100	0.185	0.201
L	0.410	0.650	0.016	0.026
θ	0°	6°	0°	6°

Package SOP14



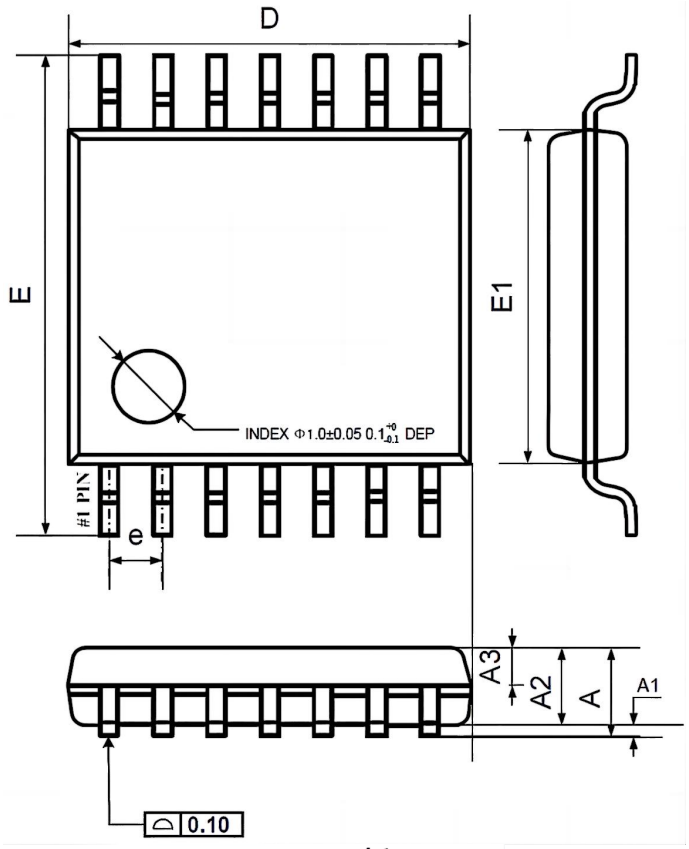


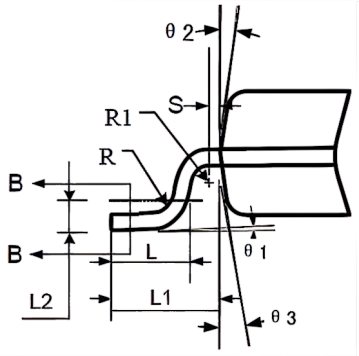


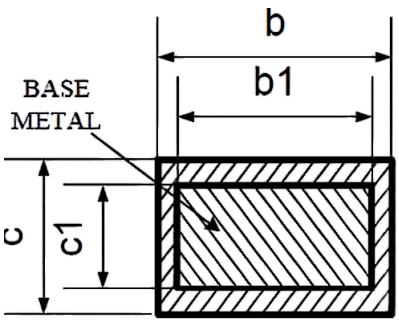


Symbol	Dimensions In Millimeters		
	MIN	NOM	MAX
A	1.35	1.60	1.75
A1	0.10	0.15	0.25
A2	1.25	1.45	1.65
A3	0.55	0.65	0.75
b	0.36		0.49
b1	0.35	0.40	0.45
C	0.16		0.25
c1	0.15	0.20	0.25
D	8.53	8.63	8.73
E	5.80	6.00	6.20
E1	3.80	3.90	4.00
e	1.27 BSC		
L	0.45	0.60	0.80
L1	1.04 REF		
L2	0.25 BSC		
R	0.07		
R1	0.07		
h	0.30	0.40	0.50
θ	0°		8°
θ1	6°	8°	10°
θ2	6°	8°	10°
θ3	5°	7°	9°
θ4	5°	7°	9°

Package TSSOP14







Symbol	Dimensions In Millimeters		
	MIN	NOM	MAX
A	—	—	1.20
A1	0.05	—	0.15
A2	0.90	1.00	1.05
A3	0.34	0.44	0.54
b	0.20	—	0.28
b1	0.20	0.22	0.24
C	0.10	—	0.19
c1	0.10	0.13	0.15
D	4.86	4.96	5.06
E	6.20	6.40	6.60
E1	4.30	4.40	4.50
e	0.65 BSC		
L	0.45	0.60	0.75
L1	1.00 REF		
L2	0.25 BSC		
R	0.09	—	—
R1	0.09	—	—
S	0.20	—	—
θ1	0°	—	8°
θ2	10°	12°	14°
θ3	10°	12°	14°

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