



**TS951  
TS952  
TS954**

## INPUT/OUTPUT RAIL TO RAIL LOW POWER OPERATIONAL AMPLIFIERS

- RAIL TO RAIL **INPUT** COMMON-MODE VOLTAGE RANGE
- RAIL TO RAIL **OUTPUT** VOLTAGE SWING
- OPERATING FROM **2.7V to 12V**
- HIGH SPEED (**3MHz, 1V/μs**)
- LOW CONSUMPTION (**0.9mA @ 3V**)
- SUPPLY VOLTAGE REJECTION RATIO : **80dB**
- ESD PROTECTION (**2kV**)
- LATCH-UP IMMUNITY
- AVAILABLE IN **SOT23-5 MICROPACKAGE**

### DESCRIPTION

The TS95x family are RAIL TO RAIL BiCMOS operational amplifiers optimized and fully specified for 3V and 5V operation.

The TS951 is housed in the space-saving 5 pins SOT23 package that makes it well suited for battery-powered systems. This micropackage simplifies the PC board design because of its ability to be placed in tight spaces (outside dimensions are : 2.8mm x 2.9mm)

### APPLICATIONS

- Set-top boxes
- Laptop/Notebook computers
- Transformer/Line drivers
- Personal entertainments (CD players)
- Portable communication (cell phones, pagers)
- Instrumentation & sensing
- Digital to Analog converter buffers
- Portable headphone speaker drivers

### ORDER CODES

Part Number	Temperature Range	Package				SOT23 Marking
		N	D	P	L	
TS951I	-40, +125°C		•		•	K101
TS952I	-40, +125°C	•	•	•		
TS954I	-40, +125°C	•	•	•		

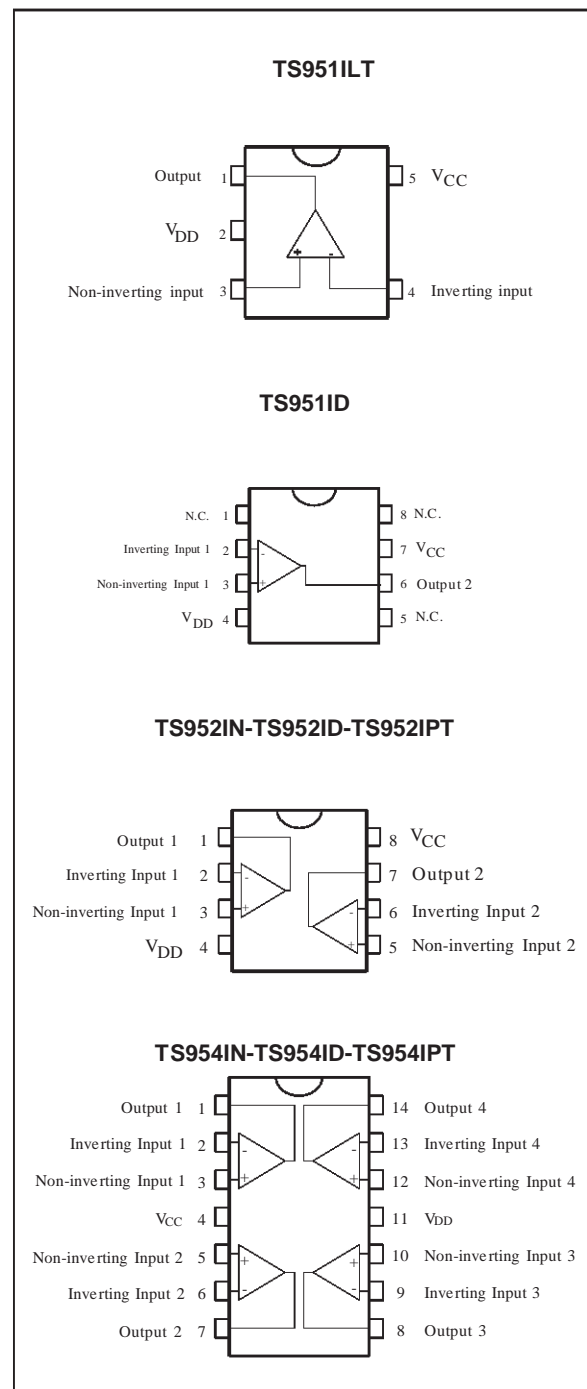
**N** = Dual in Line Package (DIP)

**D** = Small Outline Package (SO) - also available in Tape & Reel

**P** = Thin Shrink Small Outline Package (TSSOP) - only available in Tape & Reel (PT)

**L** = Tiny Package (SOT23-5) - only available in Tape & Reel (LT)

### PIN CONNECTIONS (top view)



**ABSOLUTE MAXIMUM RATINGS**

Symbol	Parameter	Value	Unit
V <sub>CC</sub>	Supply Voltage - note 1	12	V
V <sub>id</sub>	Differential Input Voltage - note 2	±1	V
V <sub>in</sub>	Input Voltage Range - note 3	-0.3 to 12.3	V
T <sub>oper</sub>	Operating Free Air Temperature Range	-40 to +125	°C
T <sub>stg</sub>	Storage Temperature Range	-65 to +150	°C
T <sub>j</sub>	Maximum Junction Temperature	150	°C
R <sub>thjc</sub>	Thermal Resistance Junction to Case - note 4 SOT23-5 SO8 SO14 TSSOP8 TSSOP14	81 28 22 26 21	°C/W
R <sub>thja</sub>	Thermal Resistance Junction to Ambient - SOT23-5	256	°C/W
ESD	Human Body Model	2	kV
	Lead Temperature (soldering, 10sec)	260	°C

- Notes:**
1. All voltages values, except differential voltage are with respect to network ground terminal.
  2. Differential voltages are non-inverting input terminal with respect to the inverting input terminal.
  3. The magnitude of input and output voltages must never exceed V<sub>CC</sub> +0.3V.
  4. Short-circuits can cause excessive heating and destructive dissipation.

**OPERATING CONDITIONS**

Symbol	Parameter	Value	Unit
V <sub>CC</sub>	Supply Voltage Range	2.7 to 12	V
V <sub>icm</sub>	Common Mode Input Voltage Range	V <sub>DD</sub> - 0.2 to V <sub>CC</sub> + 0.2	V

**ELECTRICAL CHARACTERISTICS**

$V_{CC} = +3V$ ,  $V_{DD} = 0V$ ,  $T_{amb} = 25^{\circ}C$  (unless otherwise specified)

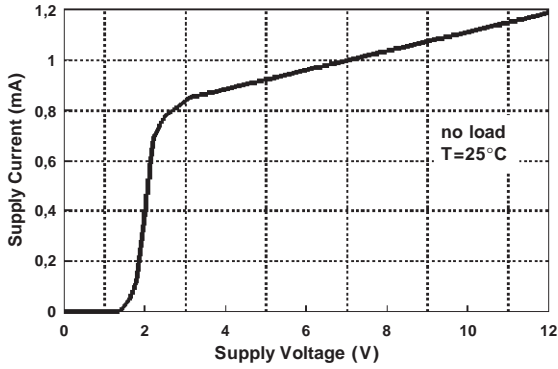
Symbol	Parameter	Min.	Typ.	Max.	Unit
$V_{io}$	Input Offset Voltage $T_{min.} \leq T_{amb} \leq T_{max.}$			6 8	mV
$DV_{io}$	Input Offset Voltage Drift		2		$\mu V/^{\circ}C$
$I_{io}$	Input Offset Current $T_{min.} \leq T_{amb} \leq T_{max.}$		1	30 80	nA
$I_{ib}$	Input Bias Current $V_{icm} = 1.5V$ $T_{min.} \leq T_{amb} \leq T_{max.}$		35	100 200	nA
$V_{icm}$	Common Mode Input Voltage Range	$V_{DD} - 0.2$ to $V_{CC} + 0.2$			V
CMR	Common Mode Rejection Ratio	50	80		dB
SVR	Supply Voltage Rejection Ratio $V_{CC} = 2.7V$ to $3.3V$	60	80		dB
$A_{vd}$	Large Signal Voltage Gain $V_o = 2V_{pk-pk}$ $R_L = 600\Omega$		80		dB
$V_{OH}$	High Level Output Voltage $R_L = 600\Omega$	2.8	2.9		V
$V_{OL}$	Low Level Output Voltage $R_L = 600\Omega$		80	250	mV
$I_{sc}$	Output Short Circuit Current	10			mA
$I_{CC}$	Supply Current (per amplifier) No load, $V_o = V_{CC}/2$		0.9	1.3	mA
GBP	Gain Bandwidth Product $R_L = 2k\Omega$		3		MHz
SR	Slew Rate		1		$V/\mu s$
$\phi_m$	Phase Margin at Unity Gain $R_L = 600\Omega$ , $C_L = 100pF$		60		Degrees
$G_m$	Gain Margin $R_L = 600\Omega$ , $C_L = 100pF$		10		dB
$e_n$	Equivalent Input Noise Voltage $f = 1kHz$		25		$\frac{nV}{\sqrt{Hz}}$
THD	Total Harmonic Distortion $V_o = 4V_{pk-pk}$ , $f = 10kHz$ , $A_V = 2$ , $R_L = 10k\Omega$		0.01		%

**ELECTRICAL CHARACTERISTICS**

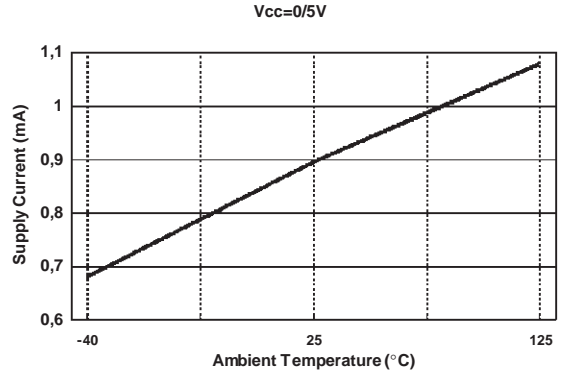
V<sub>CC</sub> = +5V, V<sub>DD</sub> = 0V, T<sub>amb</sub> = 25°C (unless otherwise specified)

Symbol	Parameter	Min.	Typ.	Max.	Unit
V <sub>io</sub>	Input Offset Voltage T <sub>min.</sub> ≤ T <sub>amb</sub> ≤ T <sub>max.</sub>			6 8	mV
DV <sub>io</sub>	Input Offset Voltage Drift		2		μV/°C
I <sub>io</sub>	Input Offset Current T <sub>min.</sub> ≤ T <sub>amb</sub> ≤ T <sub>max.</sub>		1	30 80	nA
I <sub>ib</sub>	Input Bias Current V <sub>icm</sub> = 1.5V T <sub>min.</sub> ≤ T <sub>amb</sub> ≤ T <sub>max.</sub>		35	100 200	nA
V <sub>icm</sub>	Common Mode Input Voltage Range	V <sub>DD</sub> - 0.2 to V <sub>CC</sub> + 0.2			V
CMR	Common Mode Rejection Ratio	50	80		dB
SVR	Supply Voltage Rejection Ratio V <sub>CC</sub> = 2.7V to 3.3V	60	80		dB
A <sub>vd</sub>	Large Signal Voltage Gain V <sub>o</sub> = 2Vpk-pk R <sub>L</sub> = 600Ω		86		dB
V <sub>OH</sub>	High Level Output Voltage R <sub>L</sub> = 600Ω	4.7	4.8		V
V <sub>OL</sub>	Low Level Output Voltage R <sub>L</sub> = 600Ω		80	300	mV
I <sub>sc</sub>	Output Short Circuit Current	10			mA
I <sub>CC</sub>	Supply Current (per amplifier) No load, V <sub>o</sub> = V <sub>CC</sub> /2		0.95	1.4	mA
GBP	Gain Bandwidth Product R <sub>L</sub> = 2kΩ		3		MHz
SR	Slew Rate		1		V/μs
∅ <sub>m</sub>	Phase Margin at Unity Gain R <sub>L</sub> = 600Ω, C <sub>L</sub> = 100pF		60		Degrees
G <sub>m</sub>	Gain Margin R <sub>L</sub> = 600Ω, C <sub>L</sub> = 100pF		10		dB
e <sub>n</sub>	Equivalent Input Noise Voltage f = 1kHz		25		$\frac{nV}{\sqrt{Hz}}$
THD	Total Harmonic Distortion V <sub>o</sub> = 4Vpk-pk, f = 10kHz, A <sub>V</sub> = 2, R <sub>L</sub> = 10kΩ		0.01		%

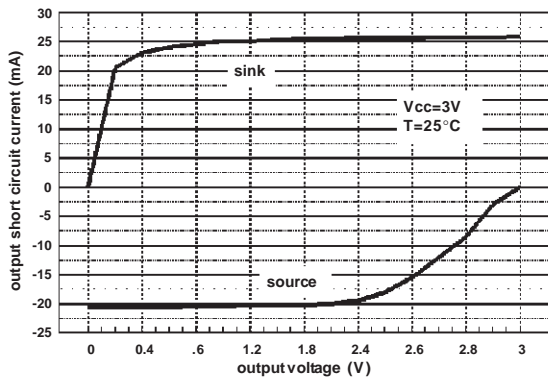
**SUPPLY CURRENT VERSUS SUPPLY VOLTAGE**



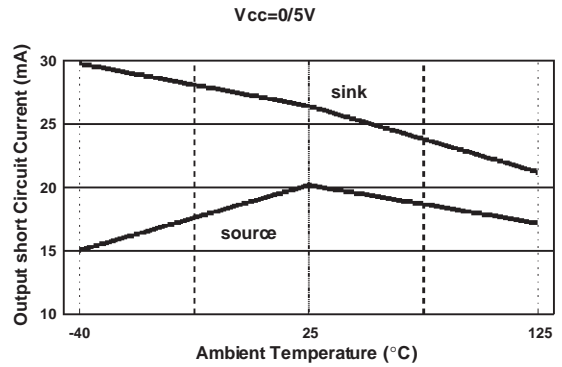
**SUPPLY CURRENT VERSUS TEMPERATURE**



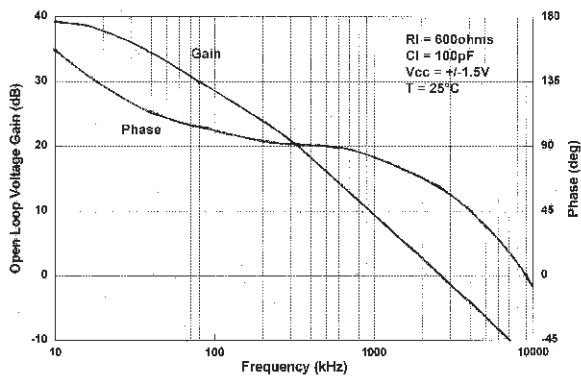
**OUTPUT SHORT CIRCUIT CURRENT VERSUS OUTPUT VOLTAGE**



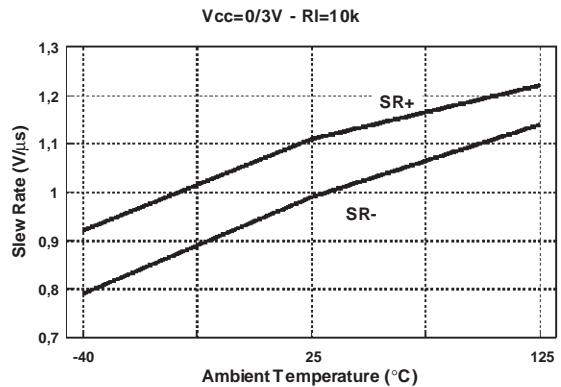
**OUTPUT SHORT CIRCUIT CURRENT VERSUS TEMPERATURE**



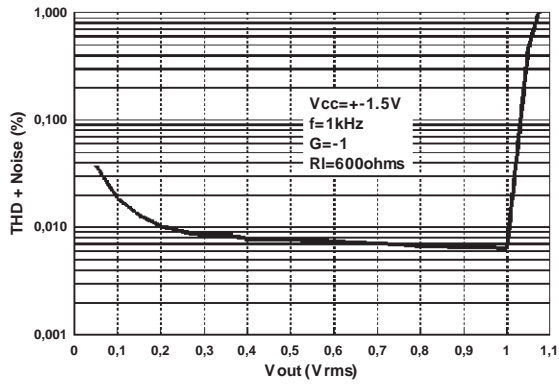
**VOLTAGE GAIN AND PHASE VERSUS FREQUENCY**



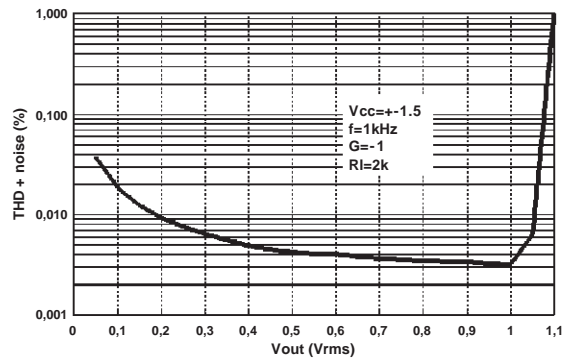
**SLEW RATE VERSUS TEMPERATURE**



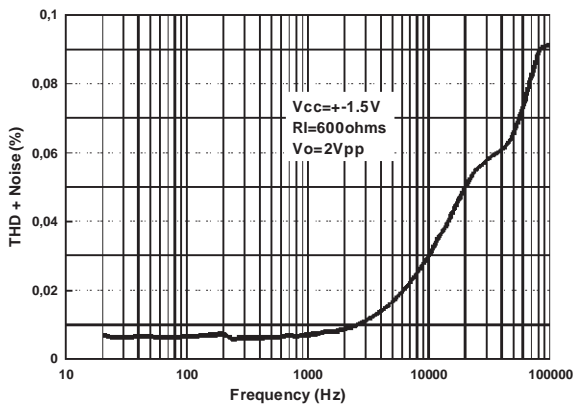
THD + NOISE VERSUS  $V_{out}$



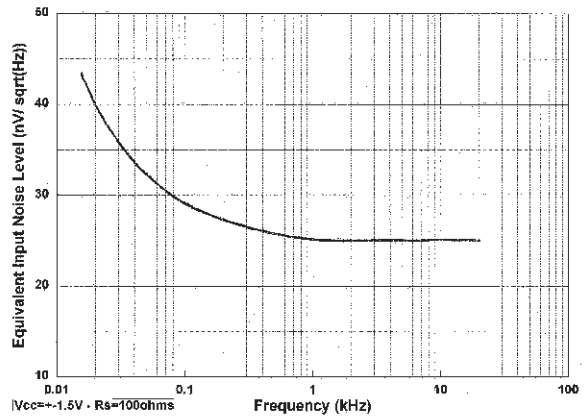
THD + NOISE VERSUS  $V_{out}$



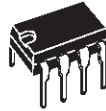
THD + NOISE VERSUS FREQUENCY



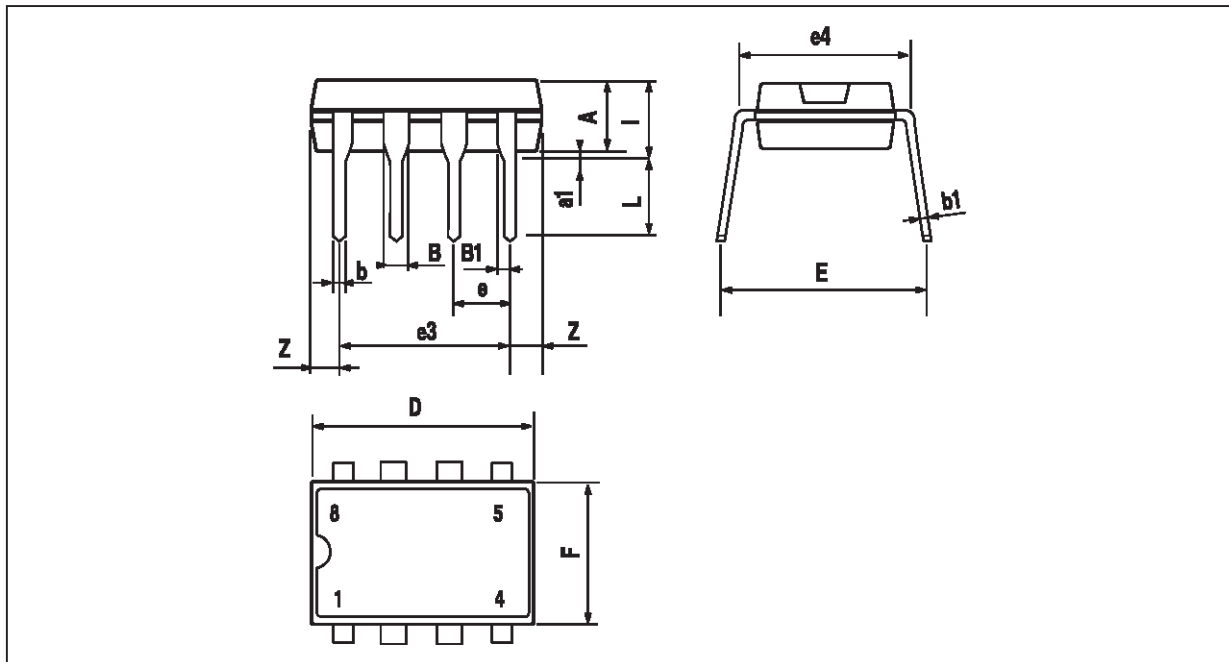
EQUIVALENT INPUT NOISE VOLTAGE VERSUS FREQUENCY



TS952IN



**PACKAGE MECHANICAL DATA**  
8 PINS - PLASTIC PACKAGE



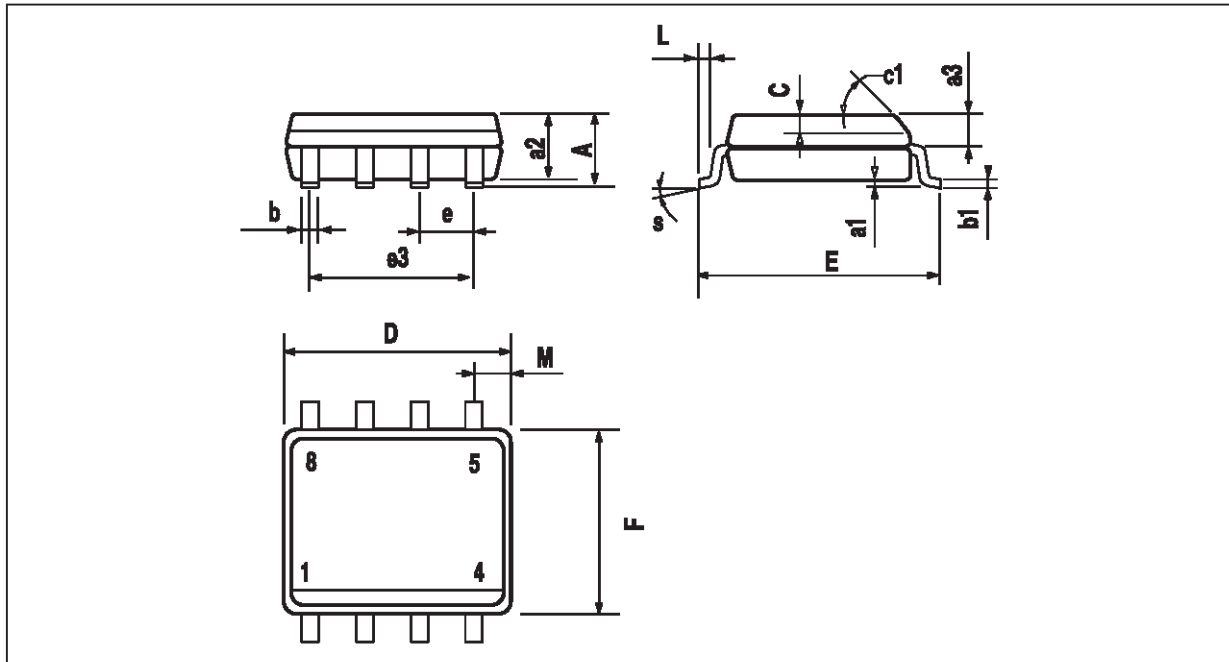
Dimensions	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A		3.32			0.131	
a1	0.51			0.020		
B	1.15		1.65	0.045		0.065
b	0.356		0.55	0.014		0.022
b1	0.204		0.304	0.008		0.012
D			10.92			0.430
E	7.95		9.75	0.313		0.384
e		2.54			0.100	
e3		7.62			0.300	
e4		7.62			0.300	
F			6.6			0.260
i			5.08			0.200
L	3.18		3.81	0.125		0.150
Z			1.52			0.060

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**TS951ID-TS952ID**



**PACKAGE MECHANICAL DATA**  
8 PINS - PLASTIC MICROPACKAGE (SO)



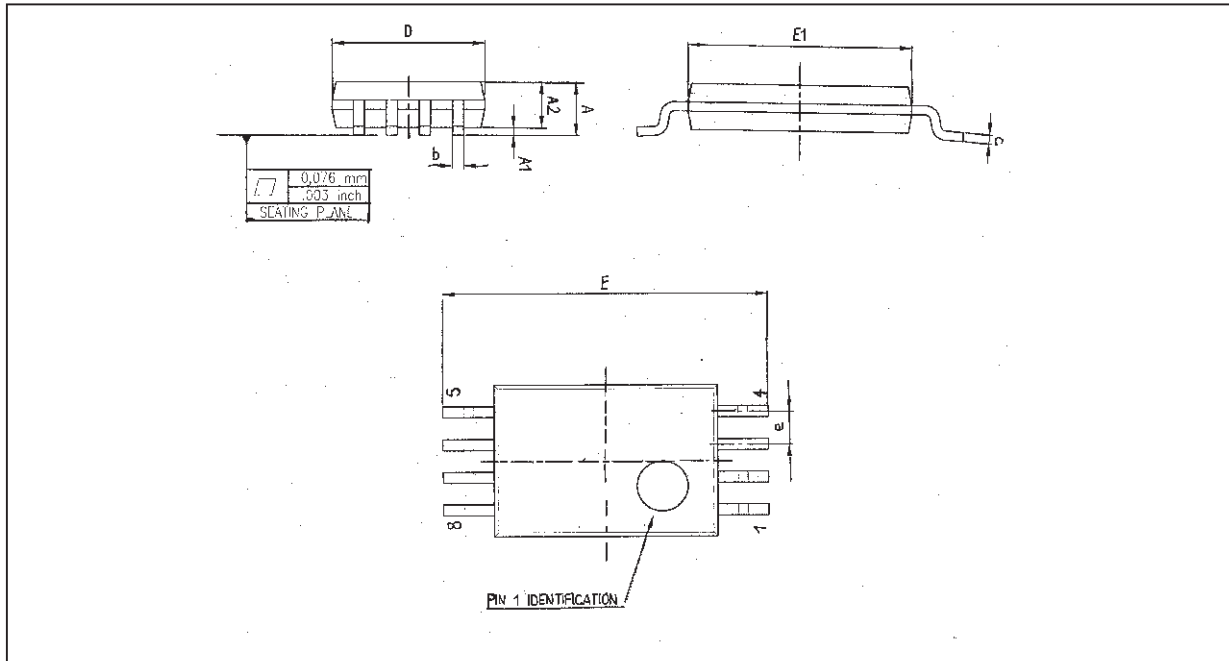
Dim.	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.75			0.069
a1	0.1		0.25	0.004		0.010
a2			1.65			0.065
a3	0.65		0.85	0.026		0.033
b	0.35		0.48	0.014		0.019
b1	0.19		0.25	0.007		0.010
C	0.25		0.5	0.010		0.020
c1	45° (typ.)					
D	4.8		5.0	0.189		0.197
E	5.8		6.2	0.228		0.244
e		1.27			0.050	
e3		3.81			0.150	
F	3.8		4.0	0.150		0.157
L	0.4		1.27	0.016		0.050
M			0.6			0.024
S	8° (max.)					



TS952IPT



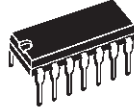
**PACKAGE MECHANICAL DATA**  
8 PINS - THIN SHRINK SMALL OUTLINE PACKAGE



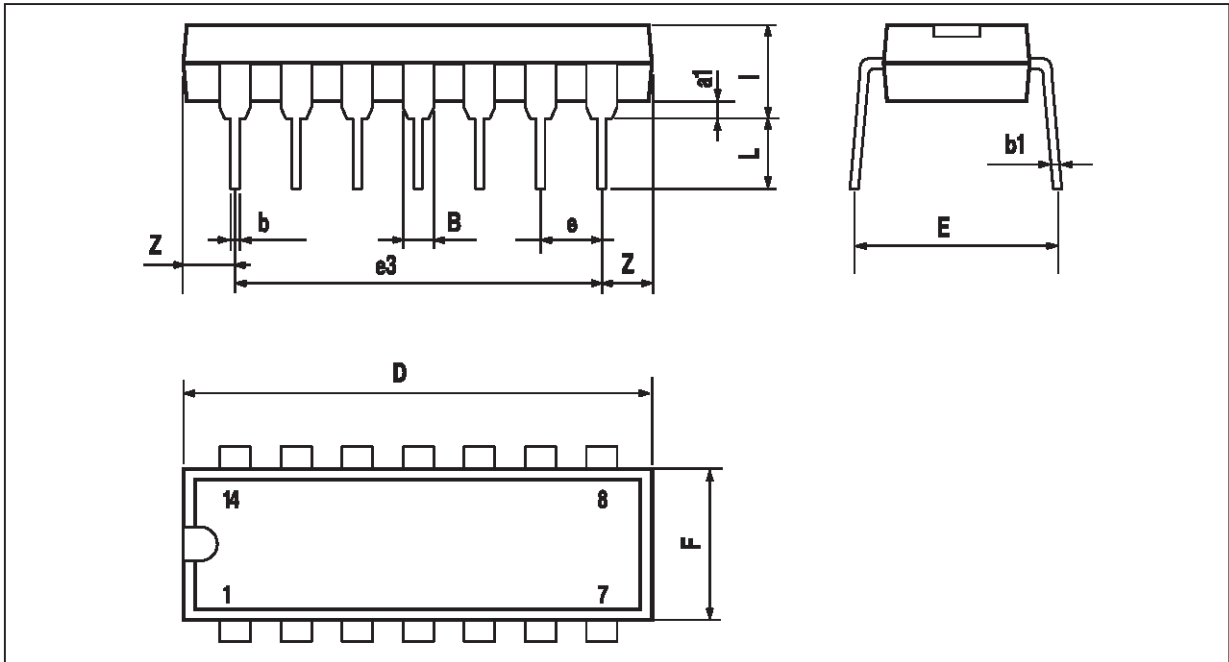
Dim.	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.20			0.05
A1	0.05		0.15	0.01		0.006
A2	0.80	1.00	1.05	0.031	0.039	0.041
b	0.19		0.30	0.007		0.15
c	0.09		0.20	0.003		0.012
D	2.90	3.00	3.10	0.114	0.118	0.122
E		6.40			0.252	
E1	4.30	4.40	4.50	0.169	0.173	0.177
e		0.65			0.025	
k	0°		8°	0°		8°
l	0.50	0.60	0.75	0.09	0.0236	0.030

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**TS954IN**



**PACKAGE MECHANICAL DATA**  
14 PINS - PLASTIC PACKAGE

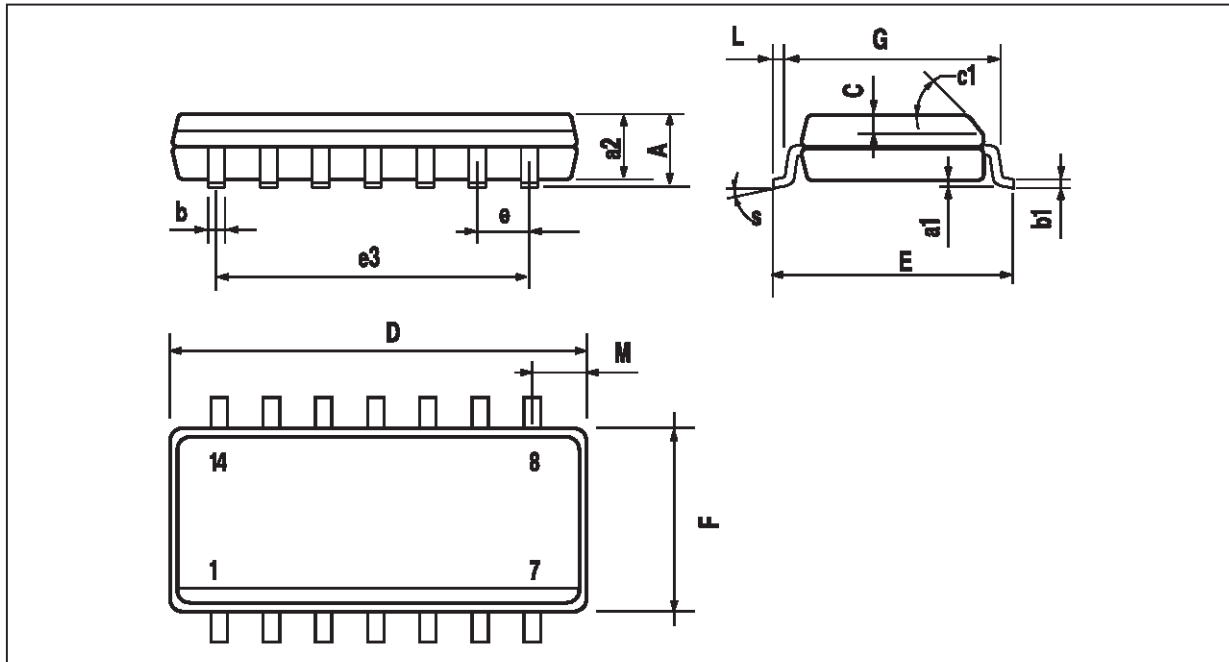


Dim.	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
a1	0.51			0.020		
B	1.39		1.65	0.055		0.065
b		0.5			0.020	
b1		0.25			0.010	
D			20			0.787
E		8.5			0.335	
e		2.54			0.100	
e3		15.24			0.600	
F			7.1			0.280
i			5.1			0.201
L		3.3			0.130	
Z	1.27		2.54	0.050		0.100

TS954ID



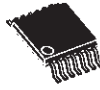
**PACKAGE MECHANICAL DATA**  
14 PINS - PLASTIC MICROPACKAGE (SO)



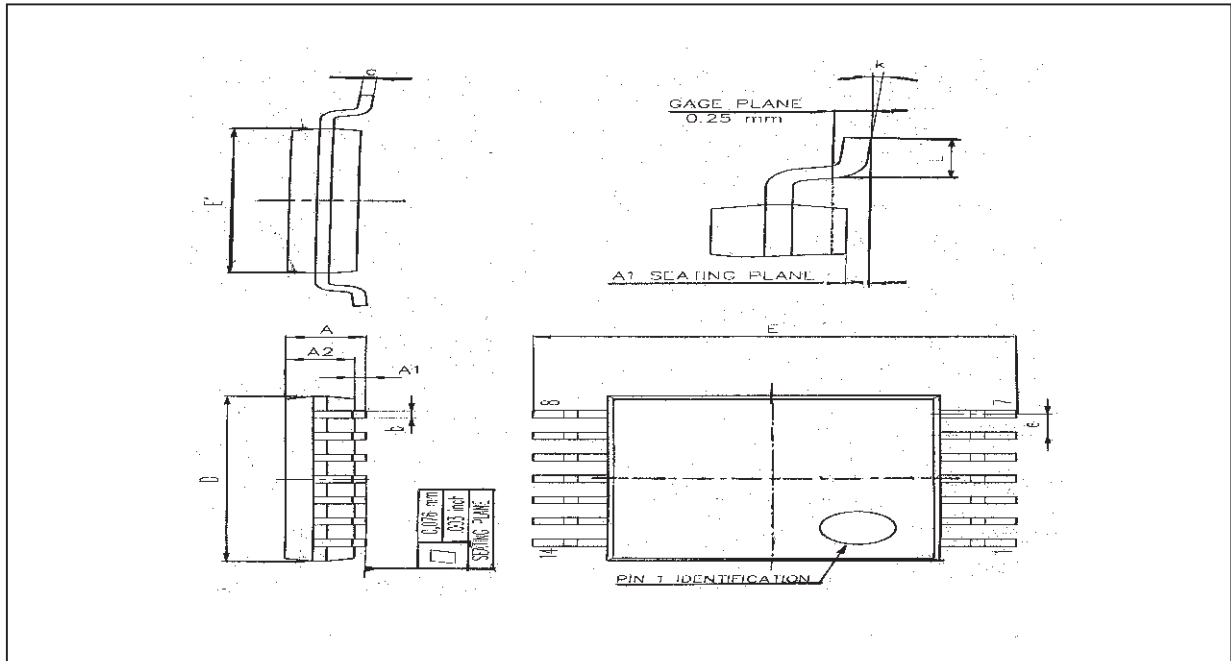
Dim.	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.75			0.069
a1	0.1		0.2	0.004		0.008
a2			1.6			0.063
b	0.35		0.46	0.014		0.018
b1	0.19		0.25	0.007		0.010
C		0.5			0.020	
c1	45° (typ.)					
D	8.55		8.75	0.336		0.334
E	5.8		6.2	0.228		0.244
e		1.27			0.050	
e3		7.62			0.300	
F	3.8		4.0	0.150		0.157
G	4.6		5.3	0.181		0.208
L	0.5		1.27	0.020		0.050
M			0.68			0.027
S	8° (max.)					

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## TS954IPT



### PACKAGE MECHANICAL DATA 14 PINS - THIN SHRINK SMALL OUTLINE PACKAGE

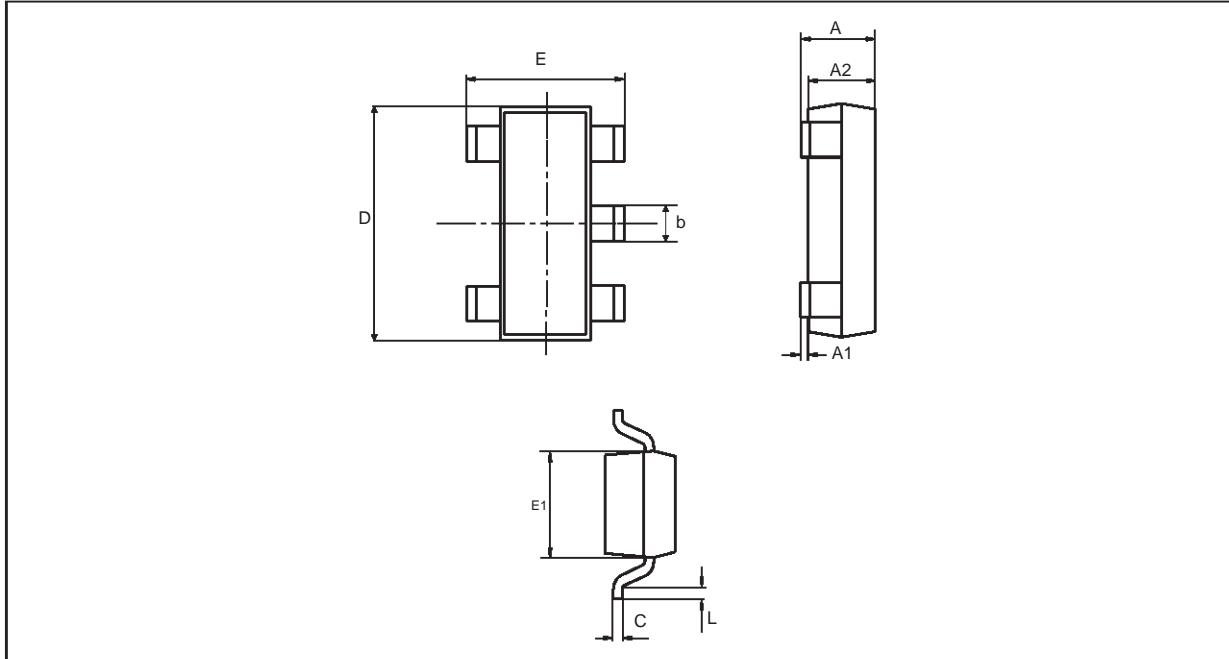


Dim.	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.20			0.05
A1	0.05		0.15	0.01		0.006
A2	0.80	1.00	1.05	0.031	0.039	0.041
b	0.19		0.30	0.007		0.15
c	0.09		0.20	0.003		0.012
D	4.90	5.00	5.10	0.192	0.196	0.20
E		6.40			0.252	
E1	4.30	4.40	4.50	0.169	0.173	0.177
e		0.65			0.025	
k	0°		8°	0°		8°
l	0.50	0.60	0.75	0.09	0.0236	0.030

TS951ILT



**PACKAGE MECHANICAL DATA**  
5 PINS -TINY PACKAGE (SOT23)



Dim.	Millimeters		Inches	
	Min.	Max.	Min.	Max.
A	0.90	1.45	0.034	0.057
A1	0	0.15		0.006
A2	0.90	1.30	0.034	0.051
b	0.35	0.50	0.013	0.020
C	0.09	0.20	0.003	0.008
D	2.80	3.00	0.110	0.118
E	2.60	3.00	0.102	0.118
E1	1.50	1.75	0.059	0.069
L	0.10	0.60	0.003	0.024

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