

# INPUT/OUTPUT RAIL TO RAIL LOW POWER OPERATIONAL AMPLIFIER

- 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

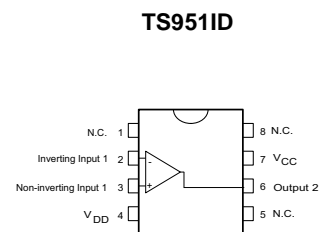
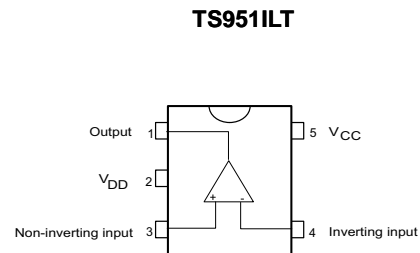
- Set-top boxes
- Laptop/Notebook computers
- Transformer/Line drivers
- Personal entertainments (CD players)
- Portable communication (cell phones, pagers)
- Instrumentation & sensing
- Digital to Analog converter buffers
- Portable headphone speaker drivers

## ORDER CODE

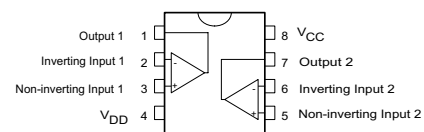
Part Number	Temperature Range	Package				SOT23 Marking
		N	D	P	L	
TS951I	-40°C, +125°C		•		•	K101
TS952I	-40°C, +125°C	•	•	•		
TS954I	-40°C, +125°C	•	•	•		

N = Dual in Line Package (DIP)  
D = Small Outline Package (SO) - also available in Tape & Reel (DT)  
P = Thin Shrink Small Outline Package (TSSOP) - only available in Tape & Reel (PT)  
L = Tiny Package (SOT23-5) - only available in Tape & Reel (LT)

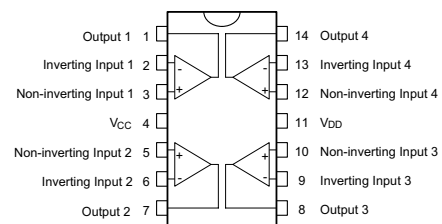
## PIN CONNECTIONS (top view)



## TS952IN-TS952ID-TS952IPT



## TS954IN-TS954ID-TS954IPT



**ABSOLUTE MAXIMUM RATINGS**

Symbol	Parameter	Value	Unit
$V_{CC}$	Supply voltage <sup>1)</sup>	12	V
$V_{id}$	Differential Input Voltage <sup>2)</sup>	$\pm 1$	V
$V_{in}$	Input Voltage <sup>3)</sup>	-0.3 to 12.3	V
$T_{oper}$	Operating Free Air Temperature Range	-40 to +125	°C
$T_{stg}$	Storage Temperature Range	-65 to +150	
$T_j$	Maximum Junction Temperature	150	°C
Rthjc	Thermal Resistance Junction to Case <sup>4)</sup>		°C/W
	SOT23-5	81	
	SO8	28	
	SO14	22	
	TSSOP8 TSSOP14	26 21	
Rthja	Thermal Resistance Junction to Ambient - SOT23-5	256	°C/W
ESD	Human Body Model	2	kV
	Lead Temperature (soldering, 10sec)	260	°C

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

**OPERATING CONDITIONS**

Symbol	Parameter	Value	Unit
$V_{CC}$	Supply voltage	2.7 to 12	V
$V_{icm}$	Common Mode Input Voltage Range	$V_{DD} - 0.2$ to $V_{CC} + 0.1$	V

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

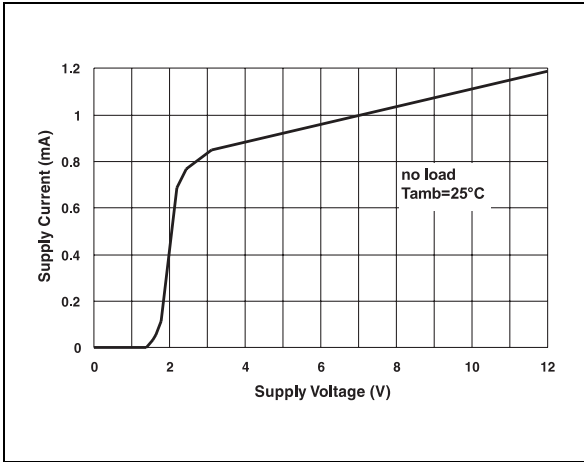
Symbol	Parameter	Min.	Typ.	Max.	Unit
$V_{io}$	Input Offset Voltage $T_{min} \leq T_{amb} \leq T_{max}$			6 8	mV
$DV_{io}$	Input Offset Voltage Drift		2		$\mu V/^{\circ}C$
$I_{io}$	Input Offset Current $T_{min} \leq T_{amb} \leq T_{max}$		1	30 80	nA
$I_{ib}$	Input Bias Current $V_{icm} = V_{cc}/2$ $T_{min} \leq T_{amb} \leq T_{max}$		35	100 200	nA
$V_{icm}$	Common Mode Input Voltage Range	$V_{DD} - 0.2$ to $V_{CC} + 0.2V$			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, $V_{icm} = V_{cc}/2$		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 Unit Gain $R_L = 600\Omega$ , $C_L = 100pF$		60		Degrees
Gm	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 $V_{out} = 4V_{pk-pk}$ , $F = 10kHz$ , $A_v = 2$ , $R_L = 10k\Omega$		0.01		%

**ELECTRICAL CHARACTERISTICS**

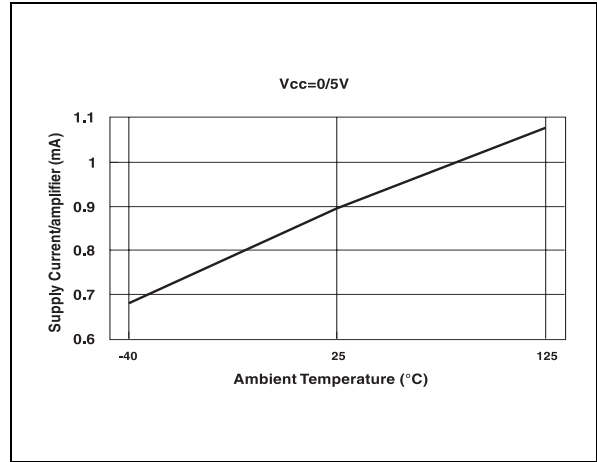
$V_{CC^+} = +5V$ ,  $V_{CC^-} = 0V$ ,  $T_{amb} = 25^{\circ}C$  (unless otherwise specified)

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 $V_{icm} = V_{cc}/2$ $T_{min} \leq T_{amb} \leq T_{max}$		1	30 80	nA
$I_{ib}$	Input Bias Current $V_{icm} = V_{cc}/2$ $T_{min} \leq T_{amb} \leq T_{max}$		35	100 200	nA
$V_{icm}$	Common Mode Input Voltage Range	$V_{DD^-} - 0.2$ to $V_{CC^+} + 0.2V$			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 $V_o = 2V_{pk-pk}$ $R_L = 600\Omega$		86		dB
$V_{OH}$	High Level Output Voltage $R_L = 600\Omega$	4.7	4.8		V
$V_{OL}$	Low Level Output Voltage $R_L = 600\Omega$		80	300	mV
$I_{sc}$	Output Short Circuit Current	10			mA
$I_{cc}$	Supply Current (per Amplifier) No load, $V_{icm} = V_{cc}/2$		0.95	1.4	mA
GBP	Gain Bandwidth Product $R_L = 2k\Omega$		3		MHz
SR	Slew Rate		1		$V/\mu s$
$\phi_m$	Phase Margin at Unit Gain $R_L = 600\Omega$ , $C_L = 100pF$		60		Degrees
Gm	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 $V_{out} = 4V_{pk-pk}$ , $F = 10kHz$ , $A_v = 2$ , $R_L = 10k\Omega$		0.01		%

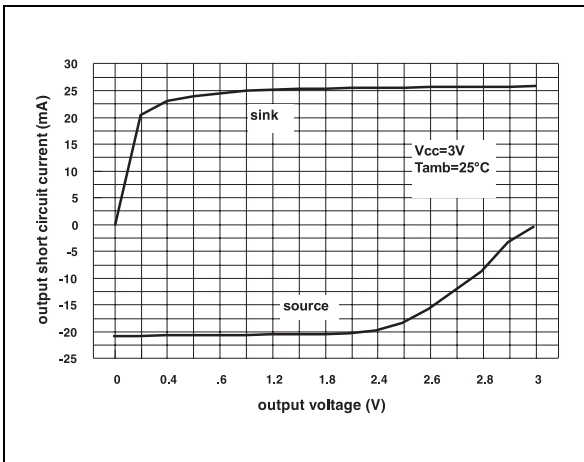
**SUPPLY CURRENT VERSUS SUPPLY VOLTAGE**



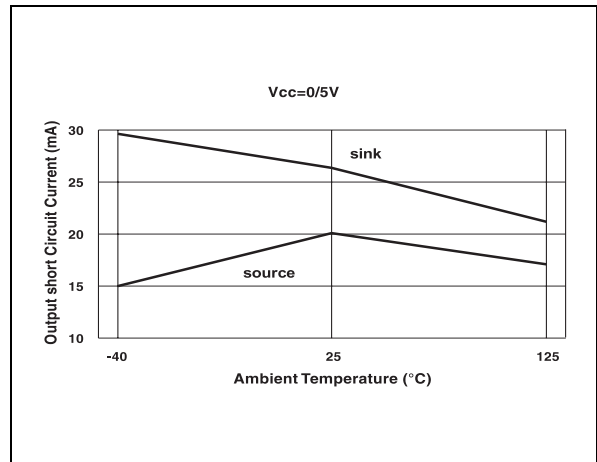
**SUPPLY CURRENT VERSUS TEMPERATURE**



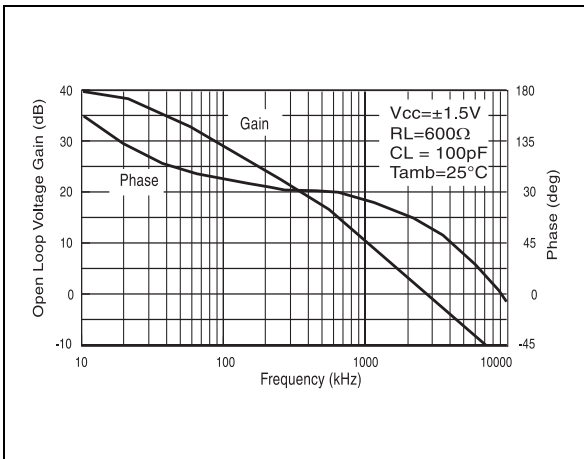
**OUTPUT SHORT CIRCUIT CURRENT VERSUS OUTPUT VOLTAGE**



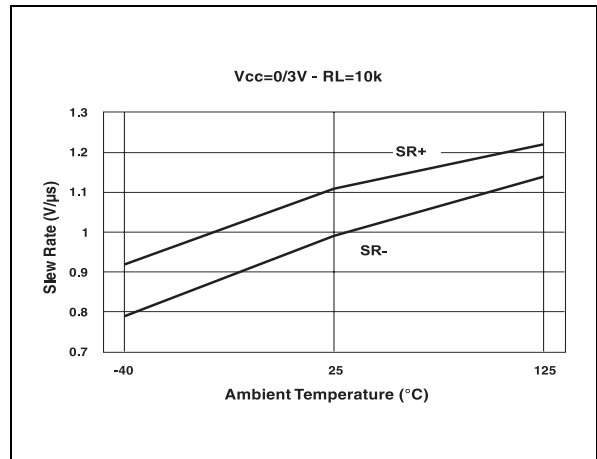
**OUTPUT SHORT CIRCUIT CURRENT VERSUS TEMPERATURE**



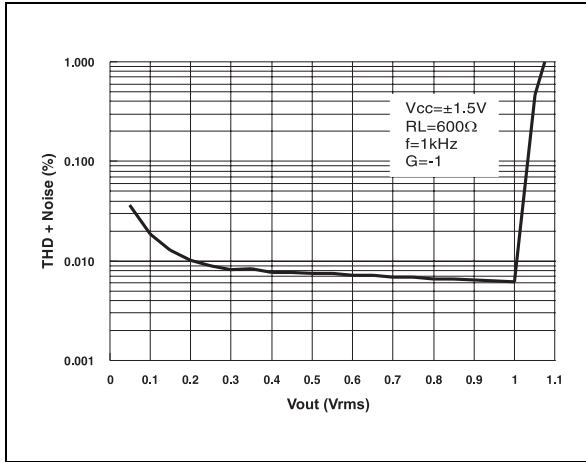
**VOLTAGE GAIN AND PHASE VERSUS FREQUENCY**



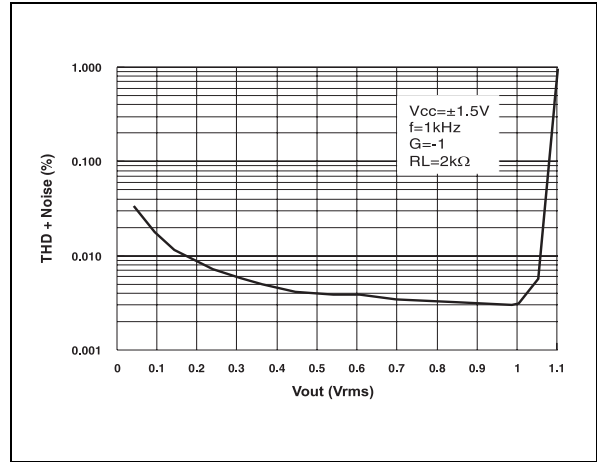
**SLEW RATE VERSUS TEMPERATURE**



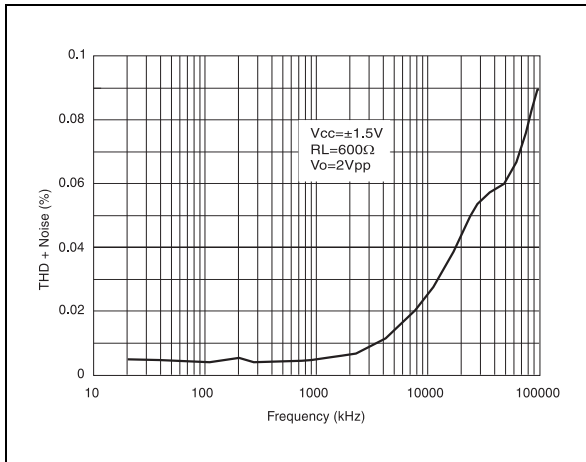
THD + NOISE VERSUS  $V_{OUT}$



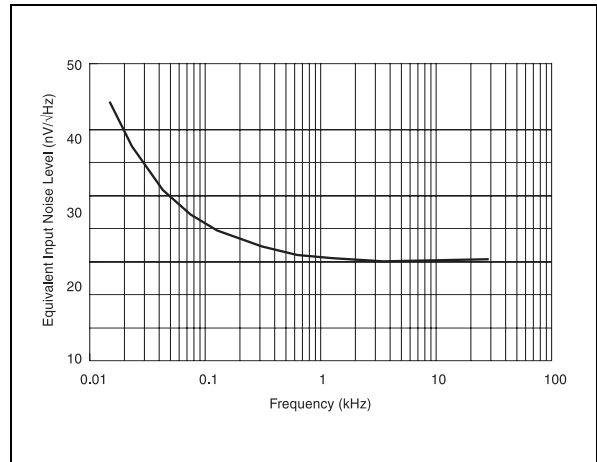
THD + NOISE VERSUS  $V_{OUT}$



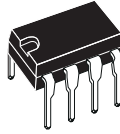
THD + NOISE VERSUS FREQUENCY



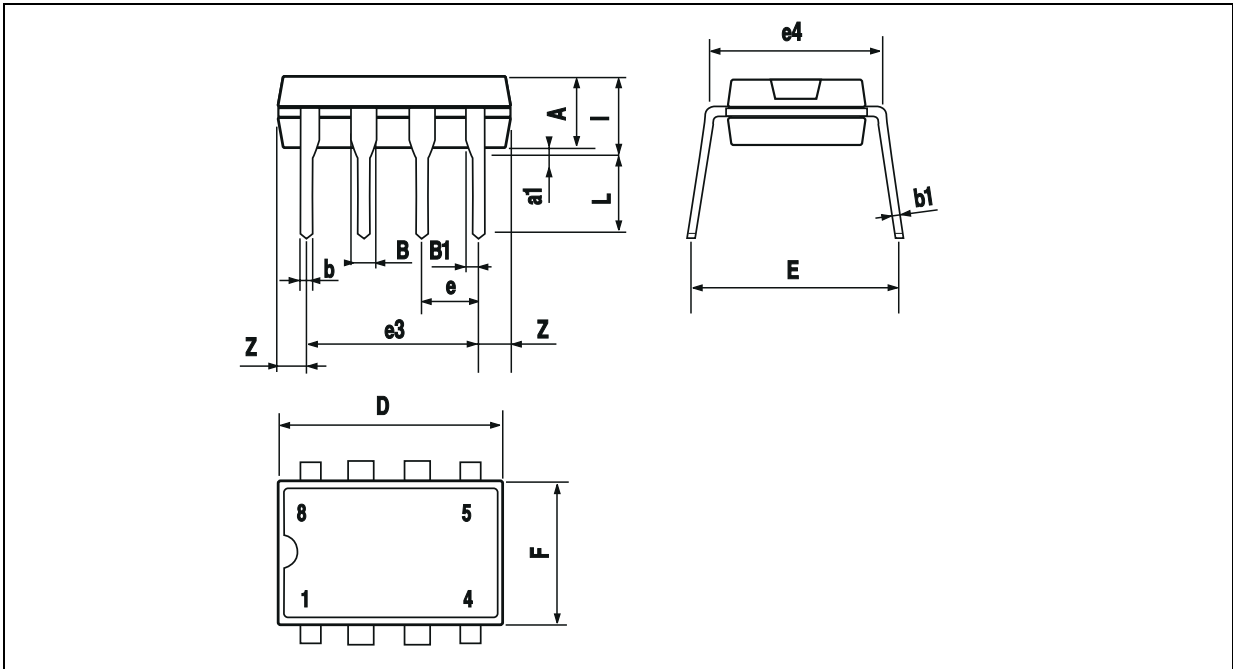
EQUIVALENT INPUT NOISE VOLTAGE VERSUS FREQUENCY



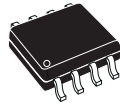
TS952IN



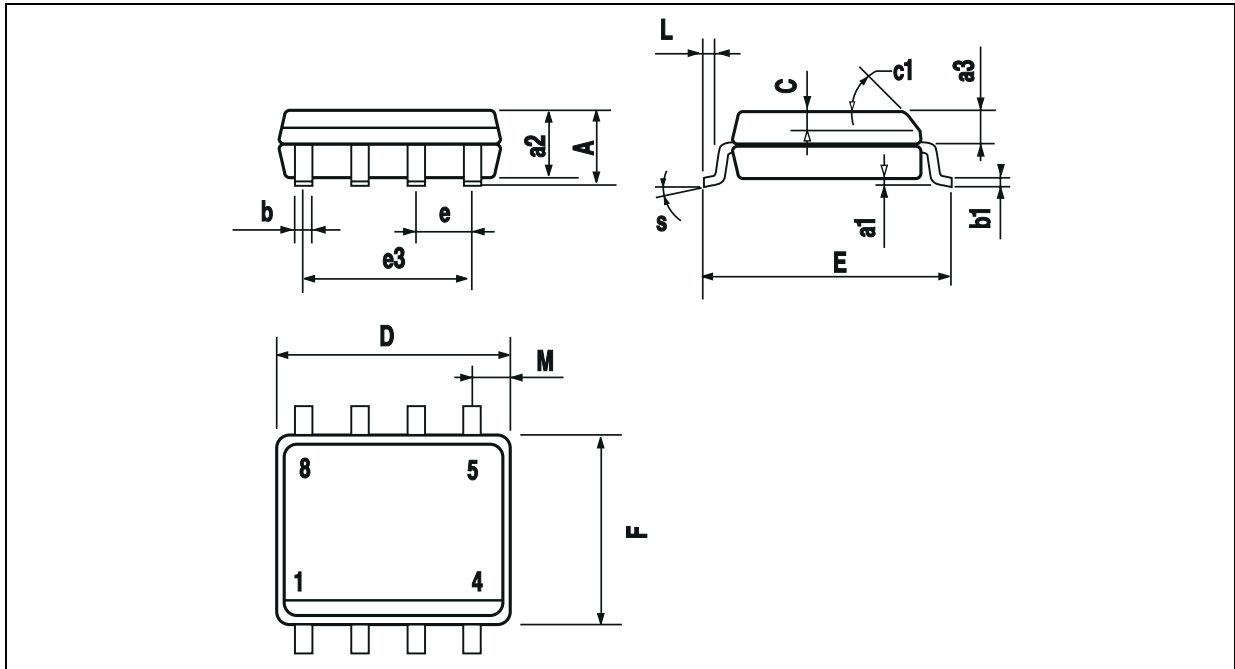
**PACKAGE MECHANICAL DATA**  
8 PINS - PLASTIC PACKAGE



Dim.	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



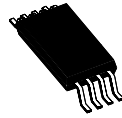
**PACKAGE MECHANICAL DATA**  
8 PINS - PLASTIC MICROPACKAGE (SO)



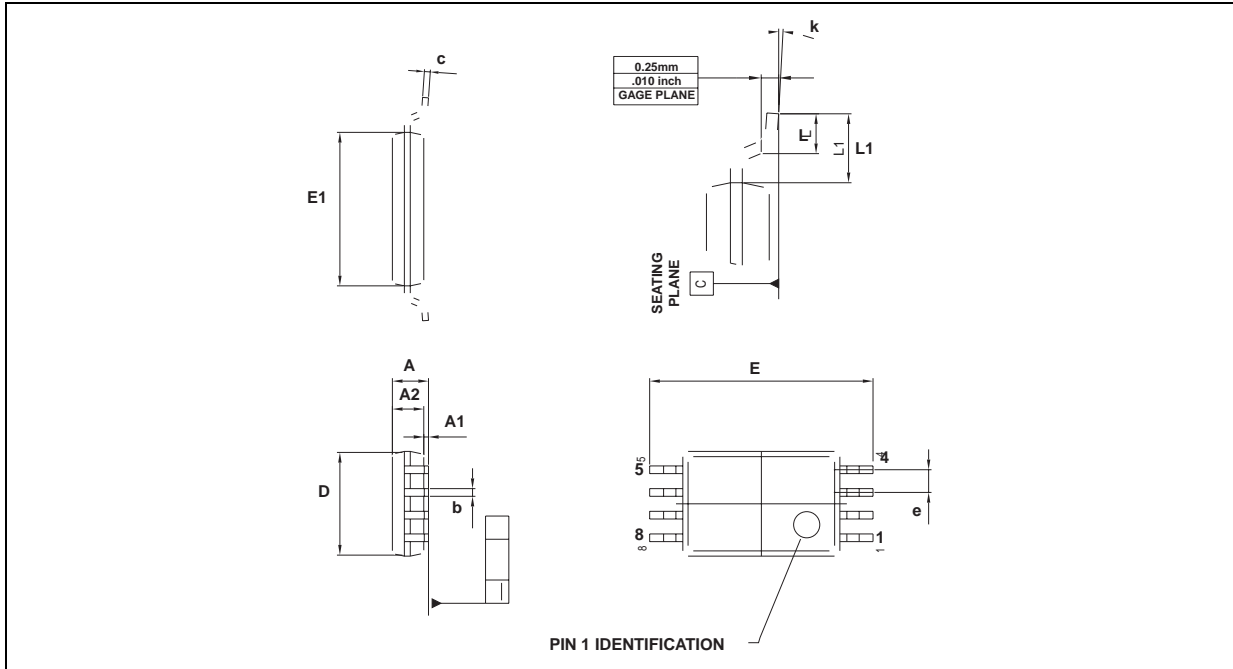
Dim.	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.75			0.069
a1	0.1		0.25	0.004		0.010
a2			1.65			0.065
a3	0.65		0.85	0.026		0.033
b	0.35		0.48	0.014		0.019
b1	0.19		0.25	0.007		0.010
C	0.25		0.5	0.010		0.020
c1	45° (typ.)					
D	4.8		5.0	0.189		0.197
E	5.8		6.2	0.228		0.244
e		1.27			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

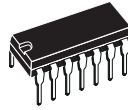


**PACKAGE MECHANICAL DATA**  
8 PINS - THIN SHRINK SMALL OUTLINE PACKAGE



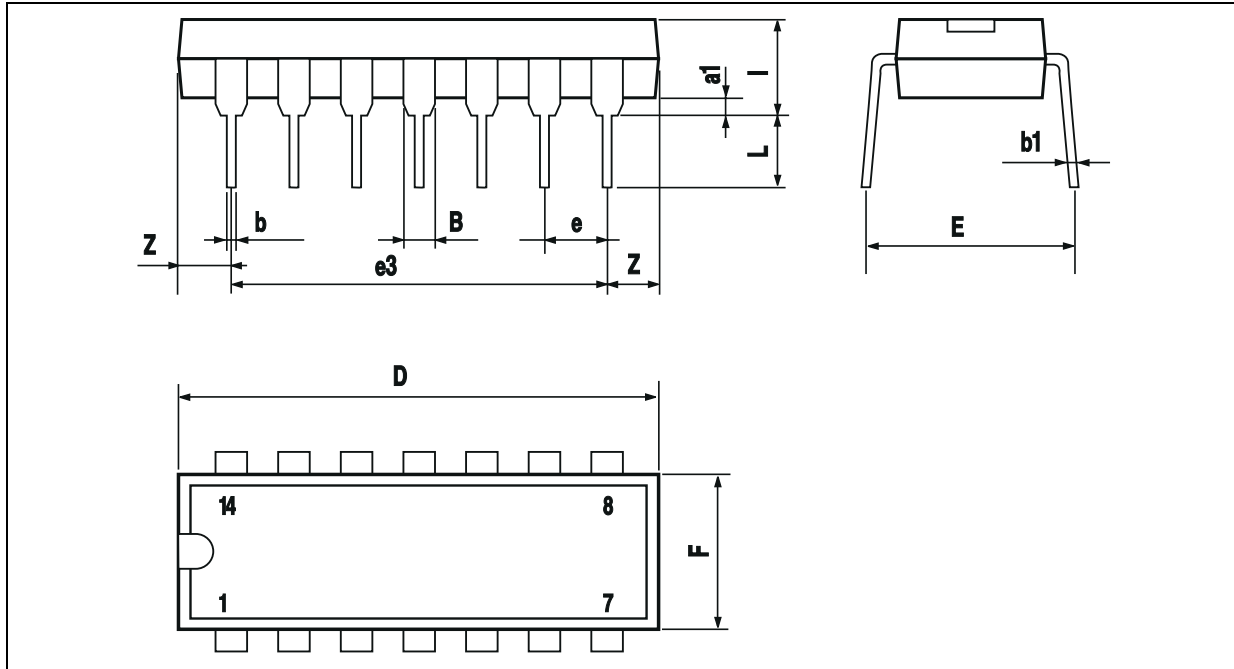
Dim.	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.20			0.05
A1	0.05		0.15	0.01		0.006
A2	0.80	1.00	1.05	0.031	0.039	0.041
b	0.19		0.30	0.007		0.15
c	0.09		0.20	0.003		0.012
D	2.90	3.00	3.10	0.114	0.118	0.122
E		6.40			0.252	
E1	4.30	4.40	4.50	0.169	0.173	0.177
e		0.65			0.025	
k	0°		8°	0°		8°
l	0.50	0.60	0.75	0.09	0.0236	0.030
L	0.45	0.600	0.75	0.018	0.024	0.030
L1		1.000			0.039	

TS954IN



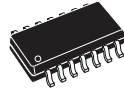
PACKAGE MECHANICAL DATA

14 PINS - PLASTIC PACKAGE

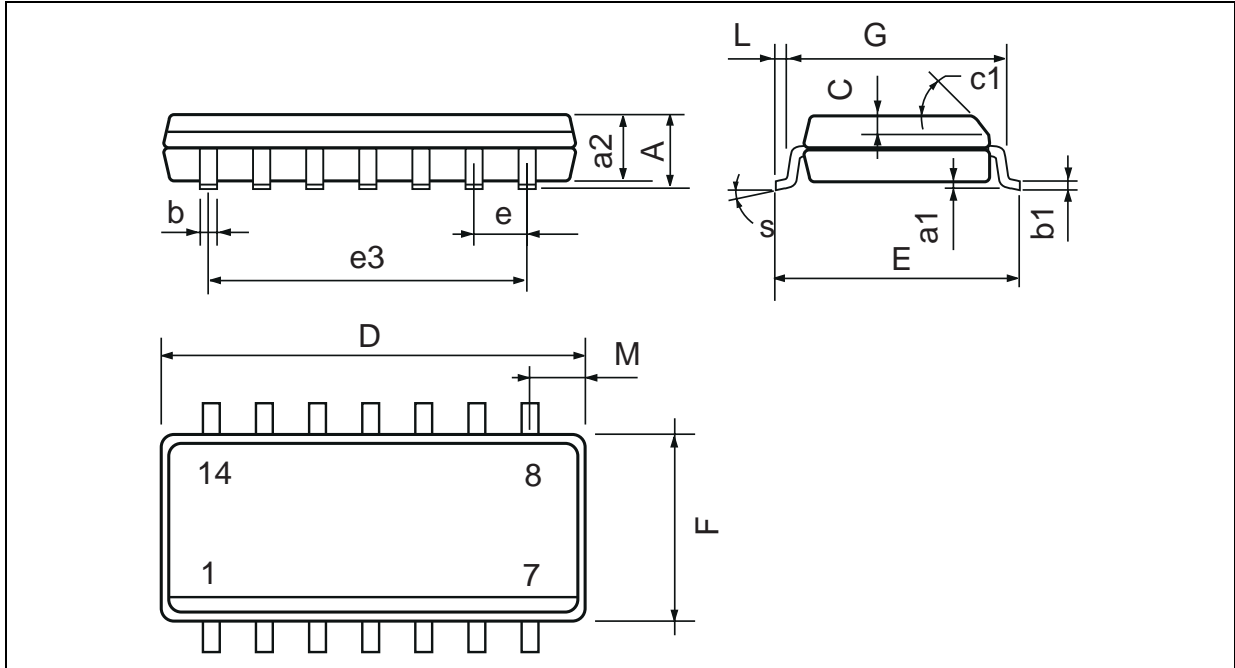


Dim.	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
a1	0.51			0.020		
B	1.39		1.65	0.055		0.065
b		0.5			0.020	
b1		0.25			0.010	
D			20			0.787
E		8.5			0.335	
e		2.54			0.100	
e3		15.24			0.600	
F			7.1			0.280
i			5.1			0.201
L		3.3			0.130	
Z	1.27		2.54	0.050		0.100

TS954ID



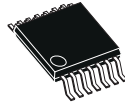
**PACKAGE MECHANICAL DATA**  
14 PINS - PLASTIC MICROPACKAGE (SO)



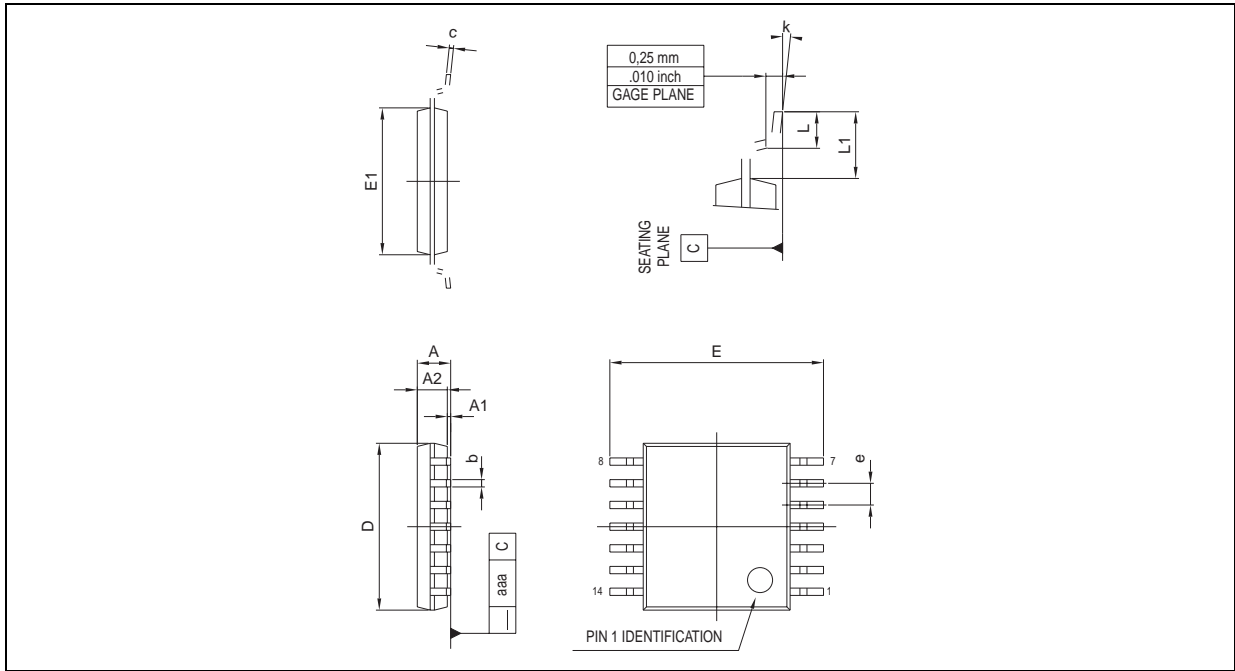
Dim.	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.75			0.069
a1	0.1		0.2	0.004		0.008
a2			1.6			0.063
b	0.35		0.46	0.014		0.018
b1	0.19		0.25	0.007		0.010
C		0.5			0.020	
c1	45° (typ.)					
D (1)	8.55		8.75	0.336		0.344
E	5.8		6.2	0.228		0.244
e		1.27			0.050	
e3		7.62			0.300	
F (1)	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.)					

Note : (1) D and F do not include mold flash or protrusions - Mold flash or protrusions shall not exceed 0.15mm (.066 inc) ONLY FOR DATA BOOK.

TS954IPT

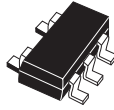


**PACKAGE MECHANICAL DATA**  
14 PINS - THIN SHRINK SMALL OUTLINE PACKAGE

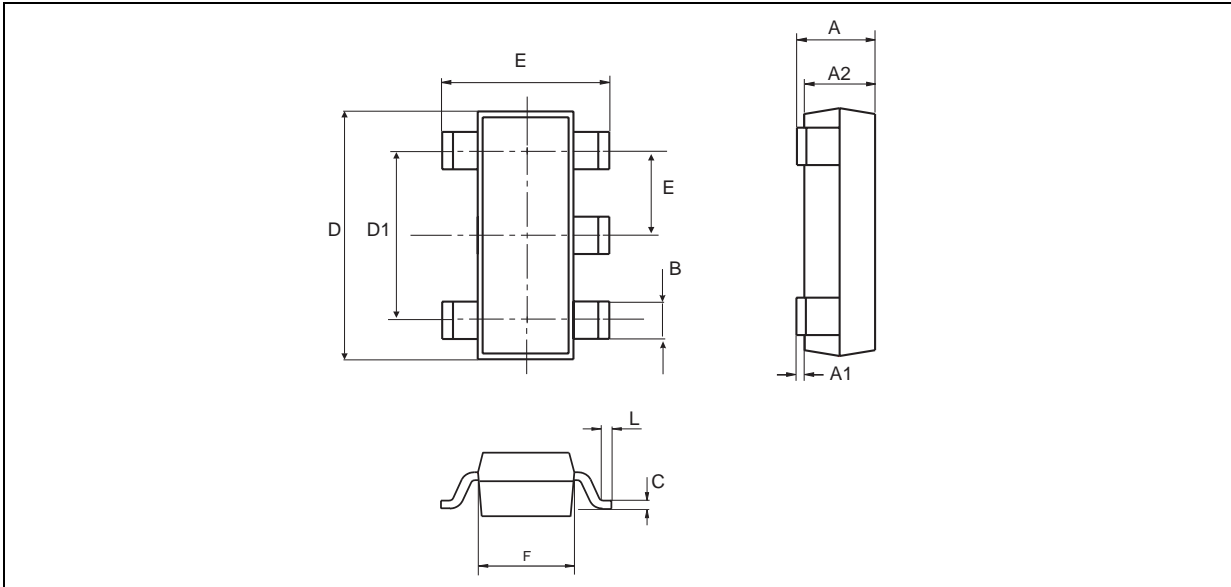


Dim.	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.20			0.05
A1	0.05		0.15	0.01		0.006
A2	0.80	1.00	1.05	0.031	0.039	0.041
b	0.19		0.30	0.007		0.15
c	0.09		0.20	0.003		0.012
D	4.90	5.00	5.10	0.192	0.196	0.20
E		6.40			0.252	
E1	4.30	4.40	4.50	0.169	0.173	0.177
e		0.65			0.025	
k	0°		8°	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.	Typ.	Max.	Min.	Typ.	Max.
A	0.90	1.20	1.45	0.035	0.047	0.057
A1	0		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	0.5	0.60	0.004	0.014	0.024
K	0d		10d	0d		10d

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