



**TS951  
TS952  
TS954**

## 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

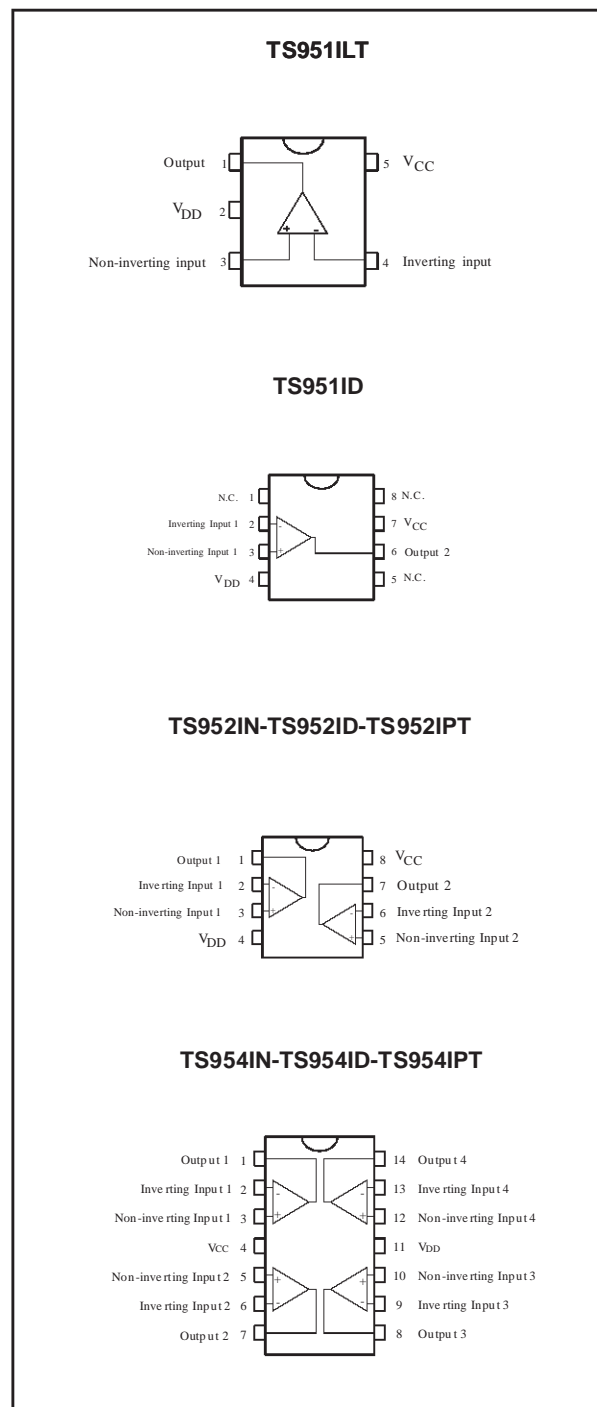
- Set-top boxes
- Laptop/Notebook computers
- Transformer/Line drivers
- Personal entertainments (CD players)
- Portable communication (cell phones, pagers)
- Instrumentation & sensing
- Digital to Analog converter buffers
- Portable headphone speaker drivers

### 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)



**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		%

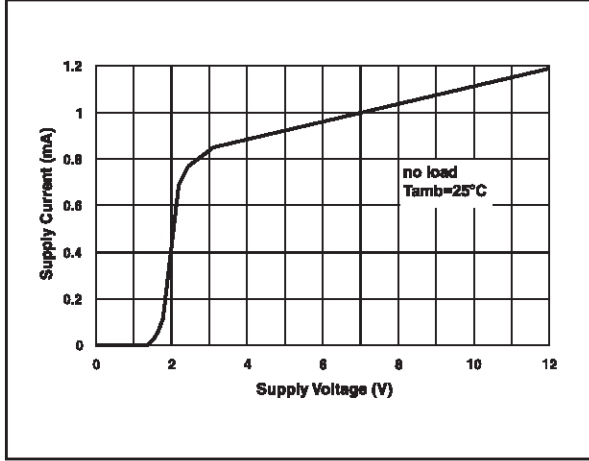
## TS951-TS952-TS954

### ELECTRICAL CHARACTERISTICS

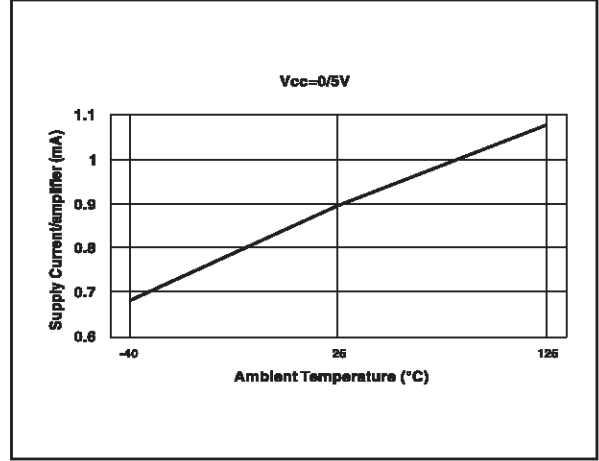
$V_{CC}^+ = +5V$ ,  $V_{CC}^- = 0V$ ,  $T_{amb} = 25^\circ C$  (unless otherwise specified)

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		%

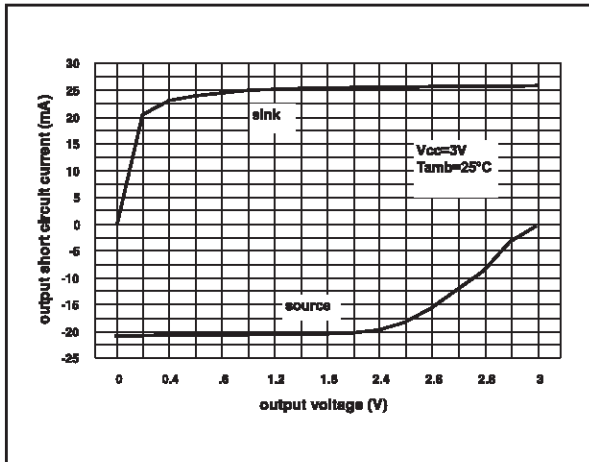
SUPPLY CURRENT VERSUS SUPPLY VOLTAGE



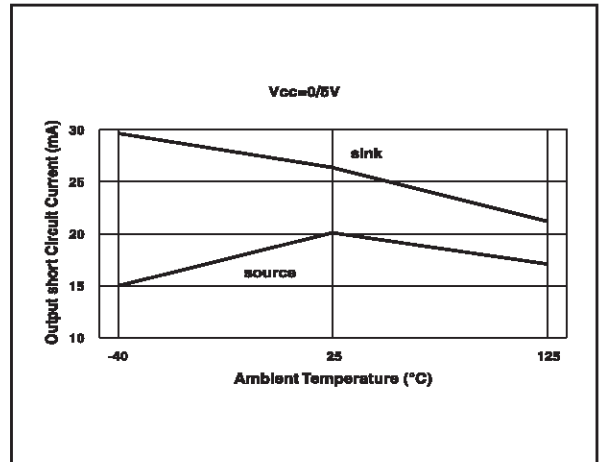
SUPPLY CURRENT VERSUS TEMPERATURE



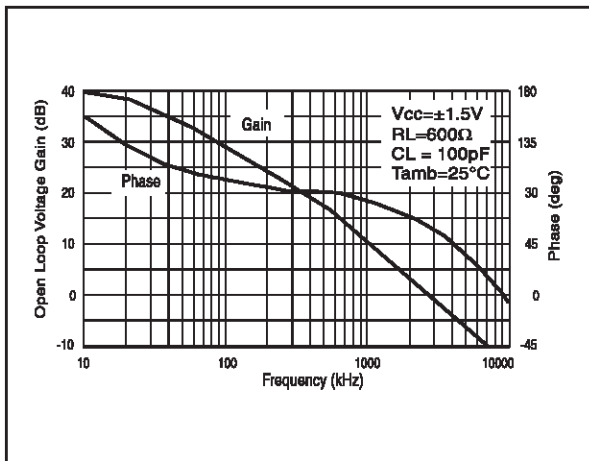
OUTPUT SHORT CIRCUIT CURRENT VERSUS OUTPUT VOLTAGE



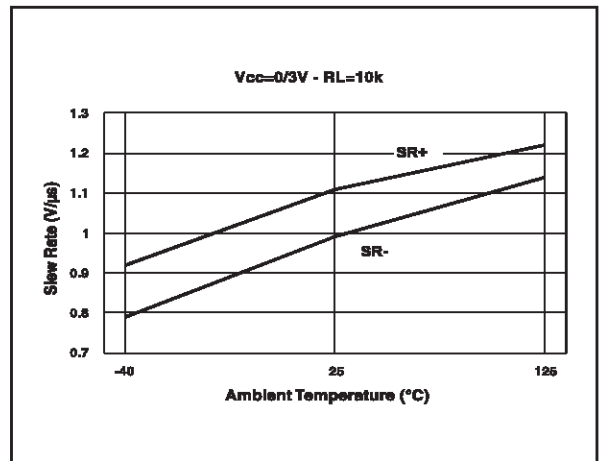
OUTPUT SHORT CIRCUIT CURRENT VERSUS TEMPERATURE



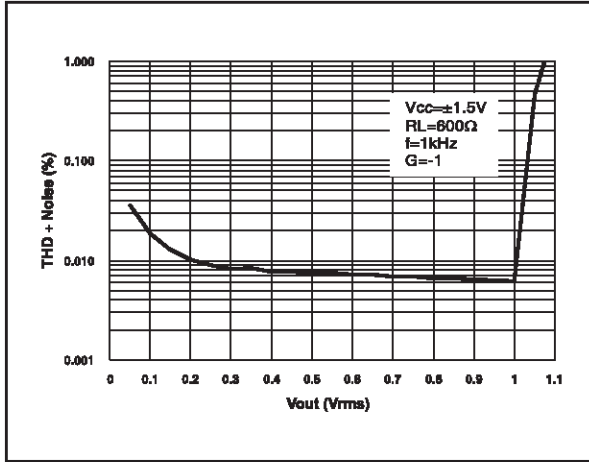
VOLTAGE GAIN AND PHASE VERSUS FREQUENCY



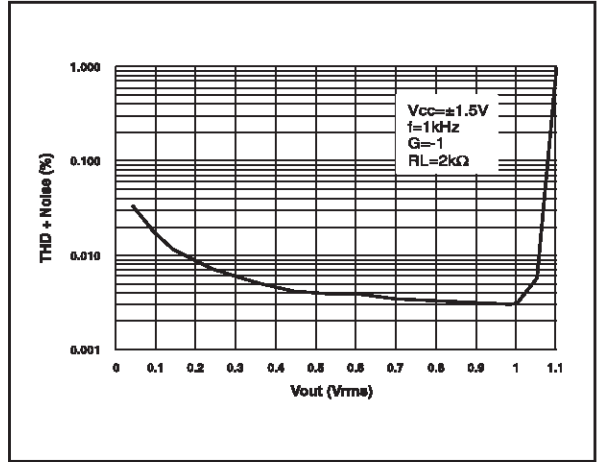
SLEW RATE VERSUS TEMPERATURE



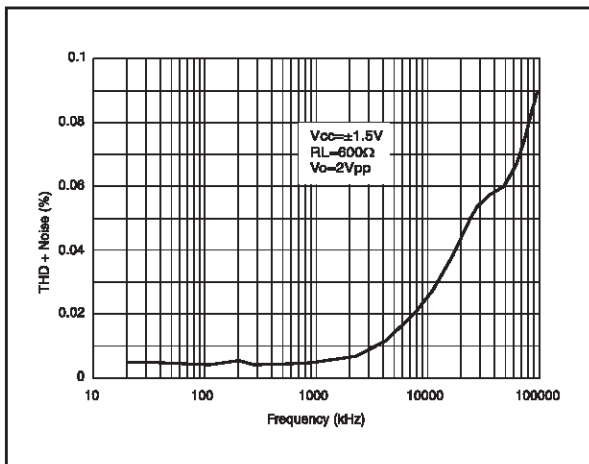
THD + NOISE VERSUS  $V_{OUT}$



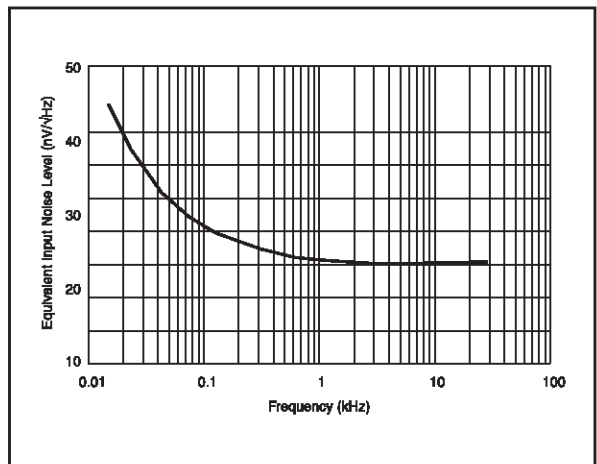
THD + NOISE VERSUS  $V_{OUT}$



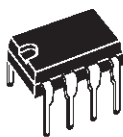
THD + NOISE VERSUS FREQUENCY



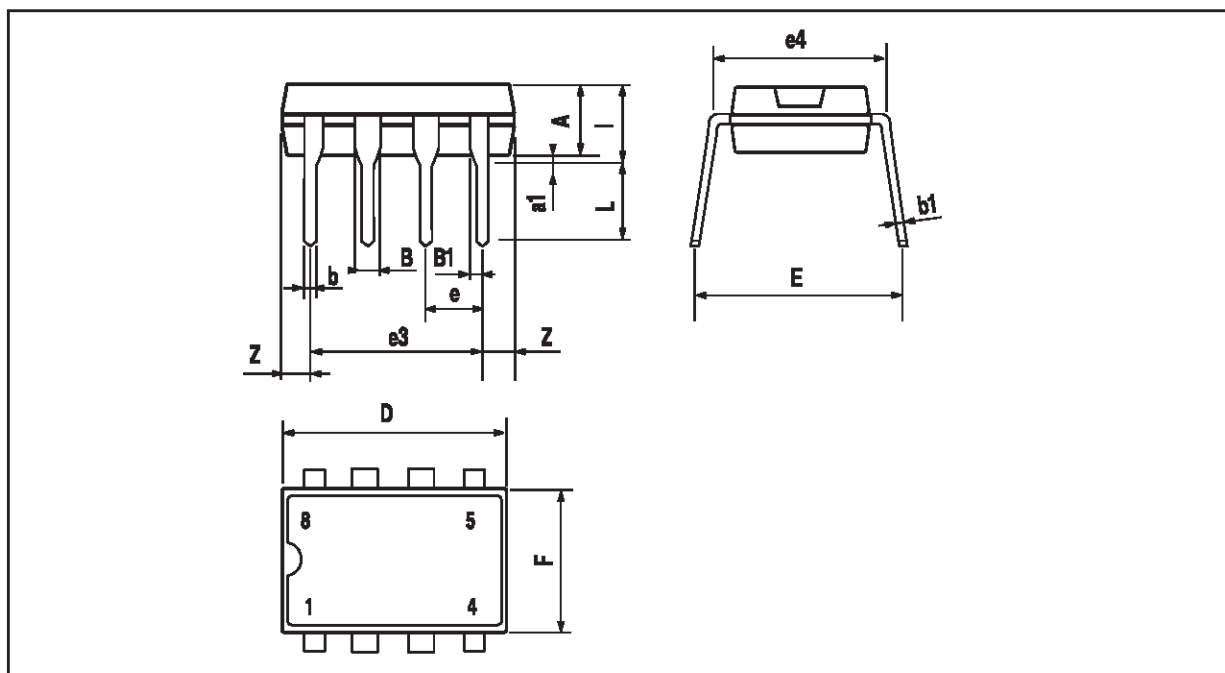
EQUIVALENT INPUT NOISE VOLTAGE VERSUS FREQUENCY



TS952IN



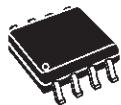
**PACKAGE MECHANICAL DATA**  
8 PINS - PLASTIC PACKAGE



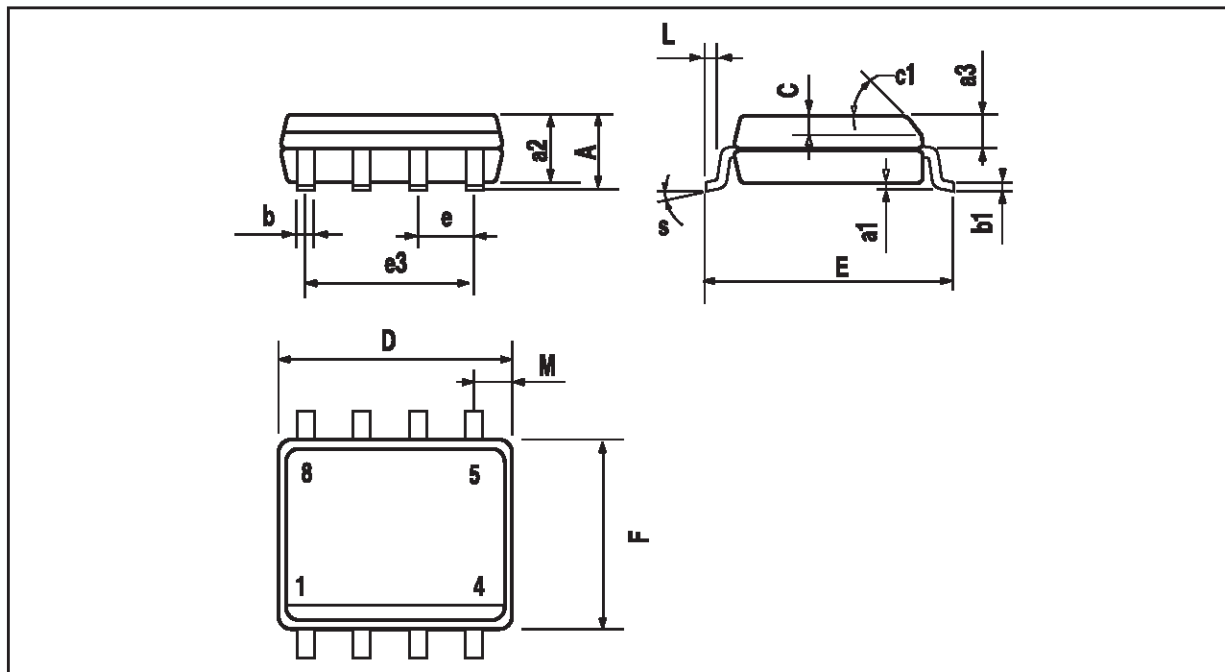
Dim.	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A		3.32			0.131	
a1	0.51			0.020		
B	1.15		1.65	0.045		0.065
b	0.356		0.55	0.014		0.022
b1	0.204		0.304	0.008		0.012
D			10.92			0.430
E	7.95		9.75	0.313		0.384
e		2.54			0.100	
e3		7.62			0.300	
e4		7.62			0.300	
F			6.6			0.260
i			5.08			0.200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

# TS951-TS952-TS954

## TS951ID-TS952ID



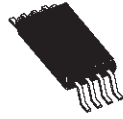
### PACKAGE MECHANICAL DATA 8 PINS - PLASTIC MICROPACKAGE (SO)



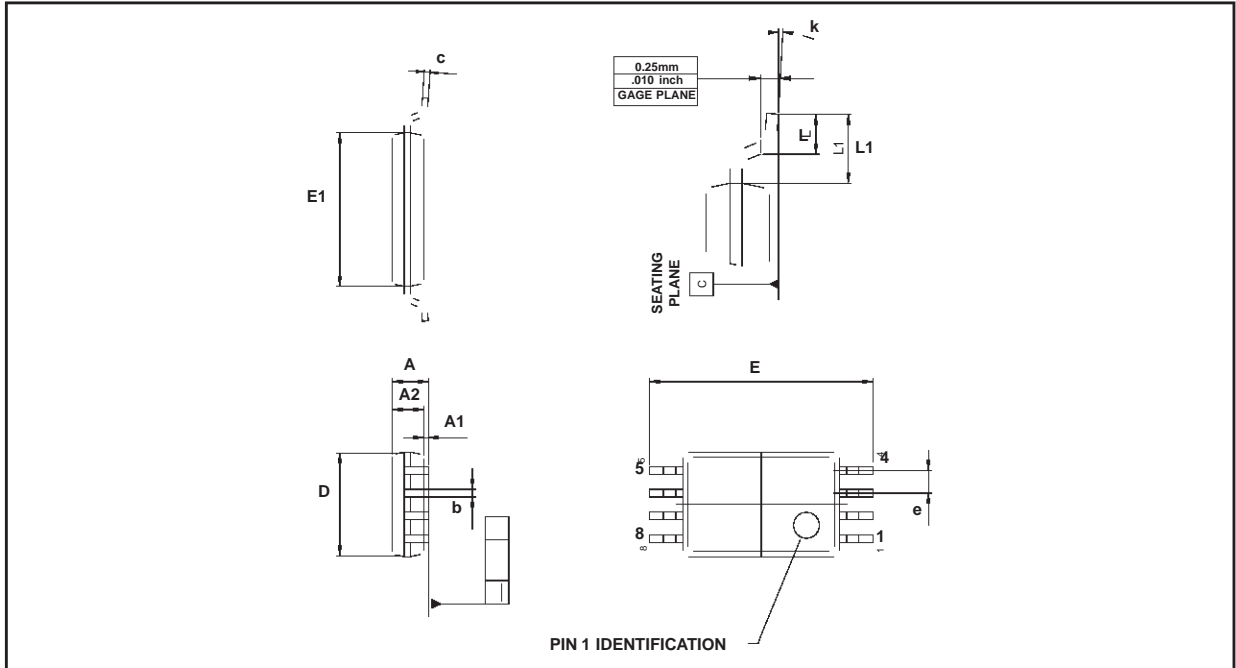
Dim.	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.75			0.069
a1	0.1		0.25	0.004		0.010
a2			1.65			0.065
a3	0.65		0.85	0.026		0.033
b	0.35		0.48	0.014		0.019
b1	0.19		0.25	0.007		0.010
C	0.25		0.5	0.010		0.020
c1	45° (typ.)					
D	4.8		5.0	0.189		0.197
E	5.8		6.2	0.228		0.244
e		1.27	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



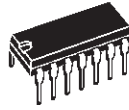
**PACKAGE MECHANICAL DATA**  
8 PINS - THIN SHRINK SMALL OUTLINE PACKAGE



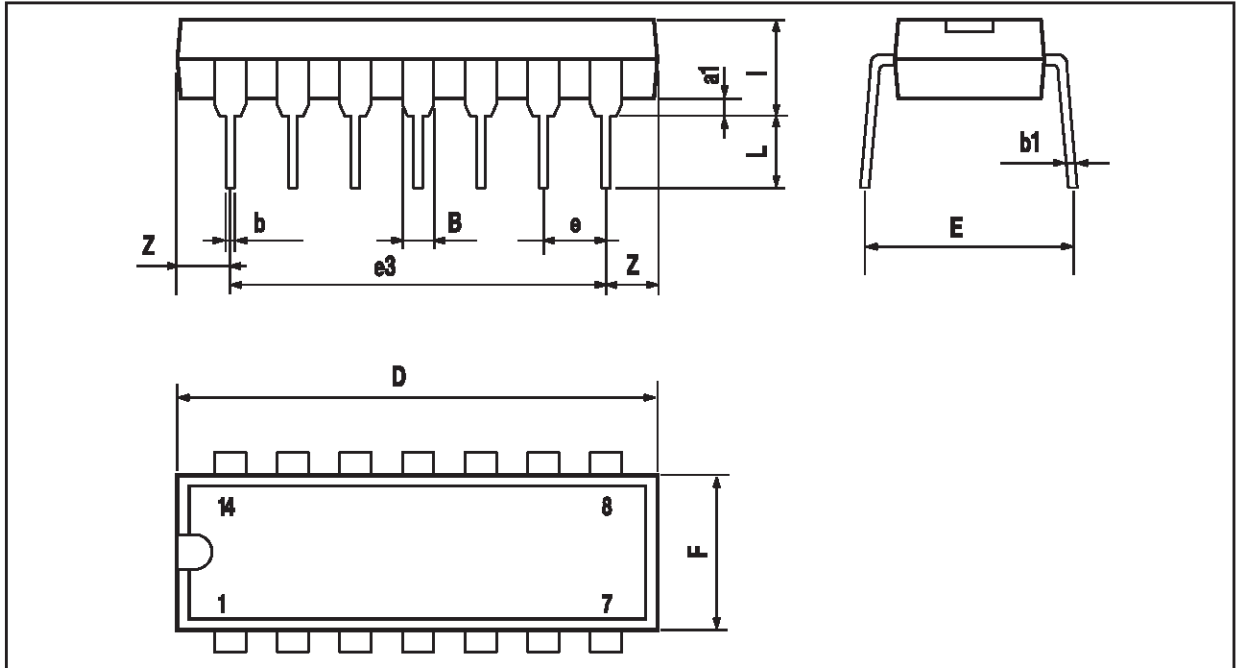
Dim.	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.20			0.05
A1	0.05		0.15	0.01		0.006
A2	0.80	1.00	1.05	0.031	0.039	0.041
b	0.19		0.30	0.007		0.15
c	0.09		0.20	0.003		0.012
D	2.90	3.00	3.10	0.114	0.118	0.122
E		6.40			0.252	
E1	4.30	4.40	4.50	0.169	0.173	0.177
e		0.65			0.025	
k	0°		8°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

# TS951-TS952-TS954

## TS954IN

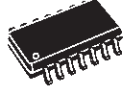


### PACKAGE MECHANICAL DATA 14 PINS - PLASTIC PACKAGE

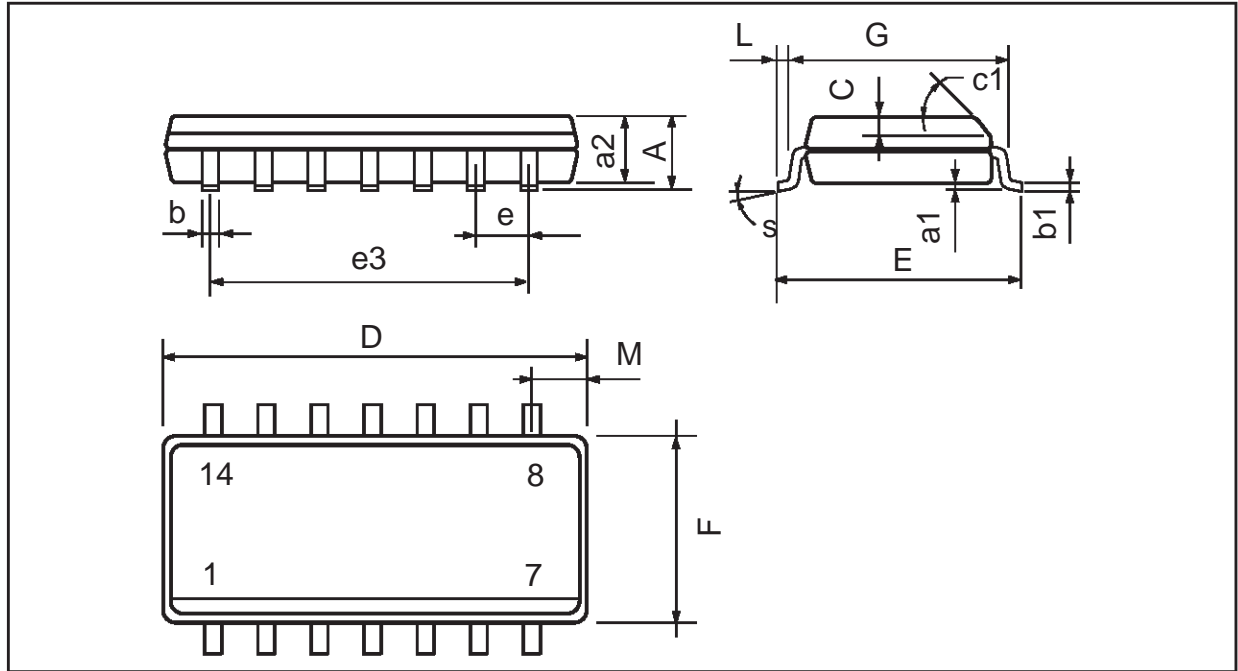


Dim.	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
a1	0.51			0.020		
B	1.39		1.65	0.055		0.065
b		0.5			0.020	
b1		0.25			0.010	
D			20			0.787
E		8.5			0.335	
e		2.54			0.100	
e3		15.24			0.600	
F			7.1			0.280
i			5.1			0.201
L		3.3			0.130	
Z	1.27		2.54	0.050		0.100

TS954ID



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

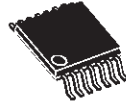


Dim.	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.75			0.069
a1	0.1		0.2	0.004		0.008
a2			1.6			0.063
b	0.35		0.46	0.014		0.018
b1	0.19		0.25	0.007		0.010
C		0.5			0.020	
c1	45° (typ.)					
D (1)	8.55		8.75	0.336		0.344
E	5.8		6.2	0.228		0.244
e		1.27			0.050	
e3		7.62			0.300	
F (1)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

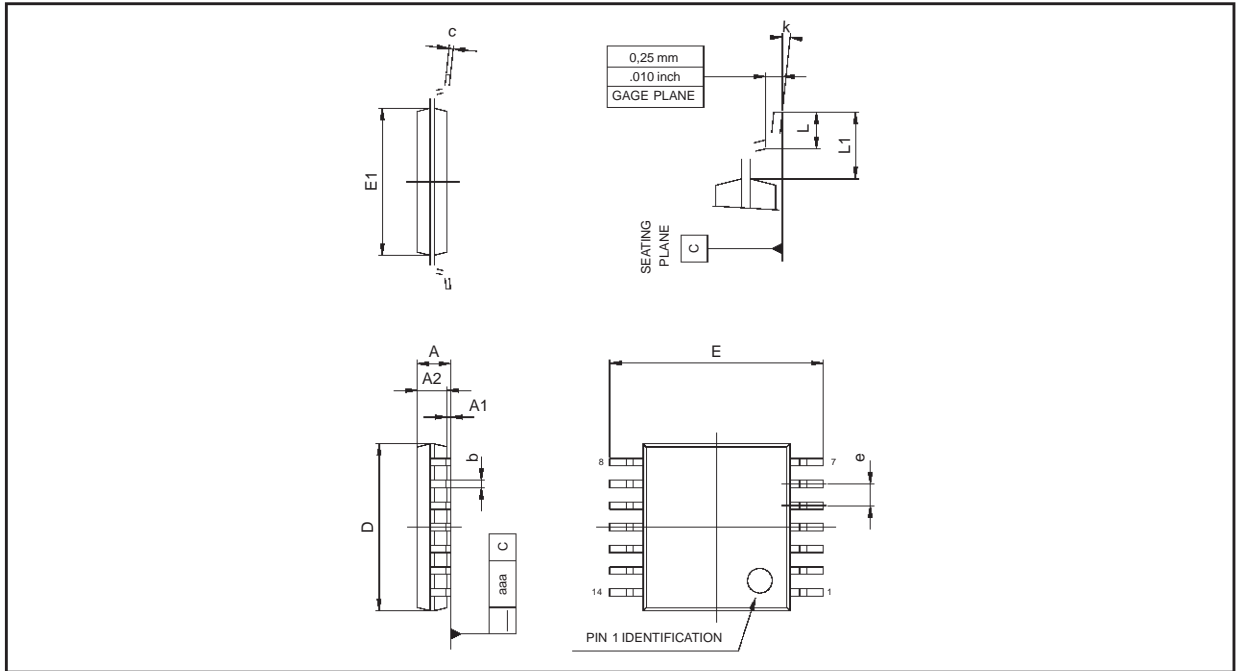
Note : (1) D and F do not include mold flash or protrusions - Mold flash or protrusions shall not exceed 0.15mm (.066 inc) ONLY FOR DATA BOOK.

**TS951-TS952-TS954**

**TS954IPT**

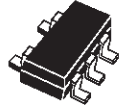


**PACKAGE MECHANICAL DATA**  
**14 PINS - THIN SHRINK SMALL OUTLINE PACKAGE**

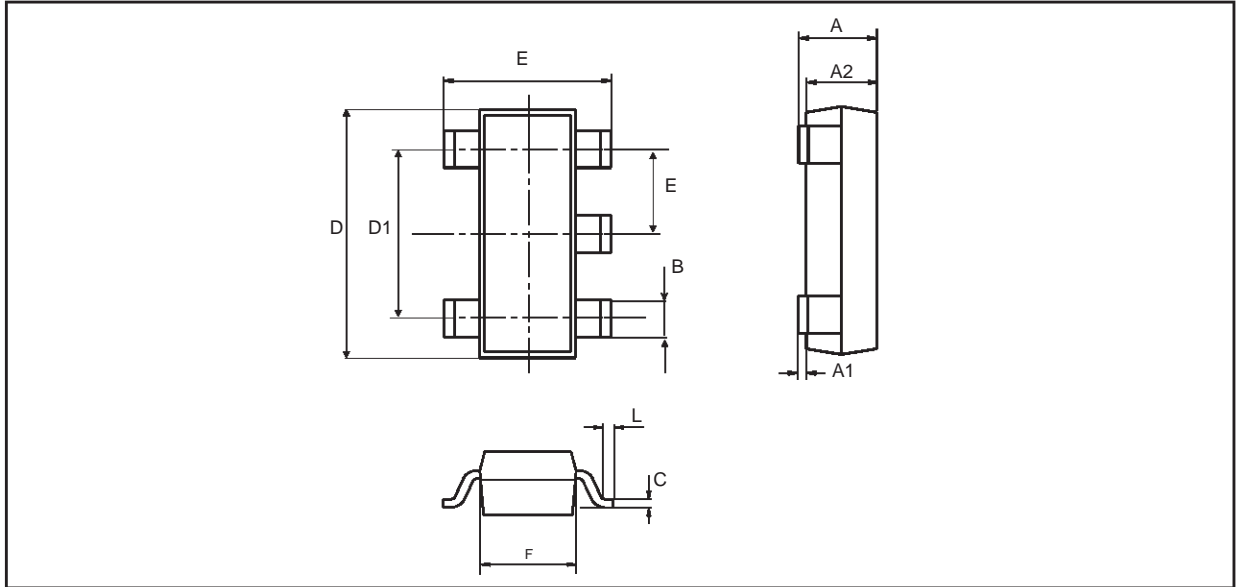


Dim.	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.20			0.05
A1	0.05		0.15	0.01		0.006
A2	0.80	1.00	1.05	0.031	0.039	0.041
b	0.19		0.30	0.007		0.15
c	0.09		0.20	0.003		0.012
D	4.90	5.00	5.10	0.192	0.196	0.20
E		6.40			0.252	
E1	4.30	4.40	4.50	0.169	0.173	0.177
e		0.65			0.025	
k	0°		8°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