



**TS971  
TS972  
TS974**

## OUTPUT RAIL TO RAIL VERY LOW NOISE OPERATIONAL AMPLIFIERS

- RAIL TO RAIL OUTPUT VOLTAGE SWING ( $\pm 2.4V$  @  $V_{CC} = \pm 2.5V$ )
- VERY LOW NOISE LEVEL :  $4nV/\sqrt{Hz}$
- ULTRA LOW DISTORTION : 0.003%
- HIGH DYNAMIC FEATURES (12MHz, 4V/ $\mu s$ )
- OPERATING RANGE : 2.7V to 12V
- ESD PROTECTION (2kV)
- LATCH-UP IMMUNITY
- AVAILABLE IN SOT23-5 MICROPACKAGE

### DESCRIPTION

The TS97x family operational amplifiers is able to operate with voltages as low as  $\pm 1.35V$  and featuring output Rail to Rail signal swing. The TS97x boasts characteristics that make them particularly well suited for portable and battery-supplied equipment. Very low noise and low distortion characteristics make them ideal for audio pre-amplification.

The TS971 is housed in the space-saving 5 pins SOT23 package which simplifies the board design because of the ability to be placed everywhere (outside dimensions are 2.8mm x 2.9mm)

### APPLICATIONS

- Portable equipments (CD players, PDA)
- Portable communications (cell phones, pagers)
- Instrumentation & sensing
- Professional audio circuits

### ORDER CODES

Part Number	Temperature Range	Package				SOT23 Marking
		N	D	P	L	
TS971I	-40, +125°C		•		•	K120
TS972I	-40, +125°C	•	•	•		
TS974I	-40, +125°C	•	•	•		

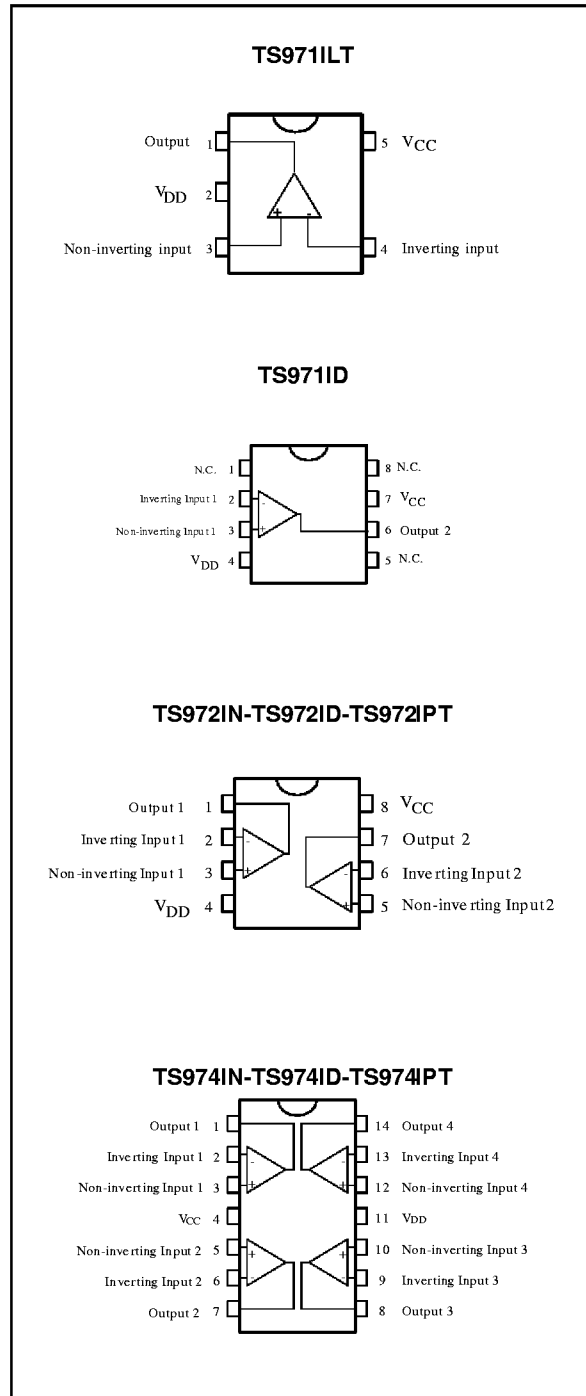
**N** = Dual in Line Package (DIP)

**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	±V <sub>CC</sub>	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		°C/W
	SOT23-5	81	
	SO8	28	
	SO14	22	
	TSSOP8	26	
	TSSOP14	21	
R <sub>thja</sub>	Thermal Resistance Junction to Ambient	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**

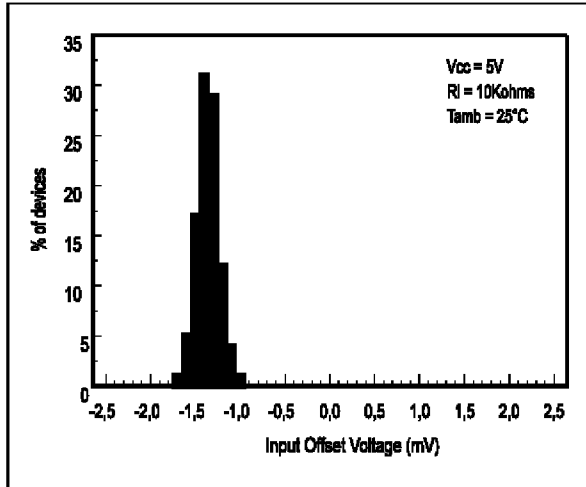
Symbol	Parameter	Value	Unit
V <sub>CC</sub>	Supply Voltage Range	2.7 to 12	V
V <sub>icm</sub>	Common Mode Input Voltage Range	V <sub>DD</sub> + 1.15 to V <sub>CC</sub> - 1.15	V

**ELECTRICAL CHARACTERISTICS**

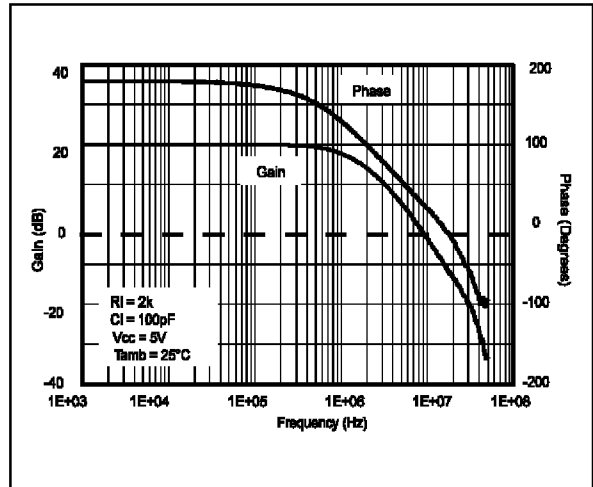
$V_{CC} = 2.5V$ ,  $V_{DD} = -2.5V$ ,  $T_{amb} = 25^{\circ}C$  (unless otherwise specified)

Symbol	Parameter	Min.	Typ.	Max.	Unit
$V_{io}$	Input Offset Voltage $T_{min.} < T_{amb} < T_{max.}$		1	5 7	mV
$DV_{io}$	Input Offset Voltage Drift $V_{icm} = 0V$ , $V_o = 0V$		5		$\mu V/^{\circ}C$
$I_{io}$	Input Offset Current $V_{icm} = 0V$ , $V_o = 0V$		10	150	nA
$I_{ib}$	Input Bias Current $V_{icm} = 0V$ , $V_o = 0V$ $T_{min.} < T_{amb} < T_{max.}$		200 200	750 1000	nA
$V_{icm}$	Common Mode Input Voltage Range	-1.35	$\pm 1.5$	1.35	V
CMR	Common Mode Rejection Ratio $V_{icm} = \pm 1.35V$	60	85		dB
SVR	Supply Voltage Rejection Ratio $V_{CC} = \pm 2V$ to $\pm 3V$	60	70		dB
$A_{vd}$	Large Signal Voltage Gain $R_L = 2k\Omega$	70	80		dB
$V_{OH}$	High Level Output Voltage $R_L = 2k\Omega$	2	2.4		V
$V_{OL}$	Low Level Output Voltage $R_L = 2k\Omega$		-2.4	-2	V
$I_{source}$	Output Source Current		1.5		mA
$I_{sink}$	Output Sink Current		100		mA
$I_{CC}$	Supply Current Unity gain - no load		2	2.8	mA
GBP	Gain Bandwidth Product $f = 100kHz$ $R_L = 2k\Omega$ , $C_L = 100pF$	8.5	12		MHz
SR	Slew Rate $A_V = 1$ , $V_{in} = \pm 1V$	2.8	4		V/ $\mu s$
$\phi_m$	Phase Margin at Unity Gain $R_L = 2k\Omega$ , $C_L = 100pF$		60		Degrees
Gm	Gain Margin $R_L = 2k\Omega$ , $C_L = 100pF$		10		dB
$e_n$	Equivalent Input Noise Voltage $f = 100kHz$		4		$\frac{nV}{\sqrt{Hz}}$
THD	Total Harmonic Distortion $f = 1kHz$ , $A_V = -1$ $R_L = 10k\Omega$		0.003		%

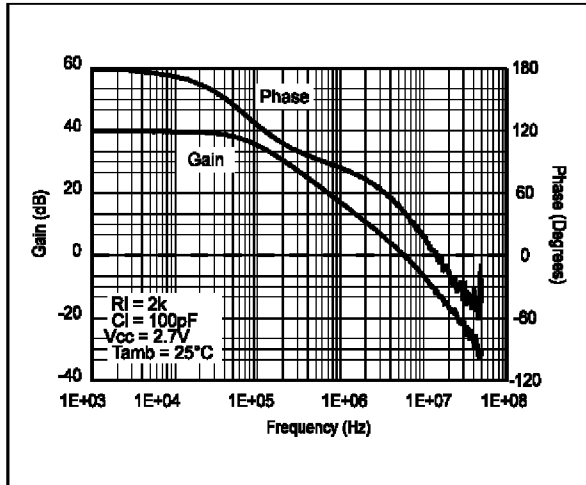
INPUT OFFSET VOLTAGE DISTRIBUTION



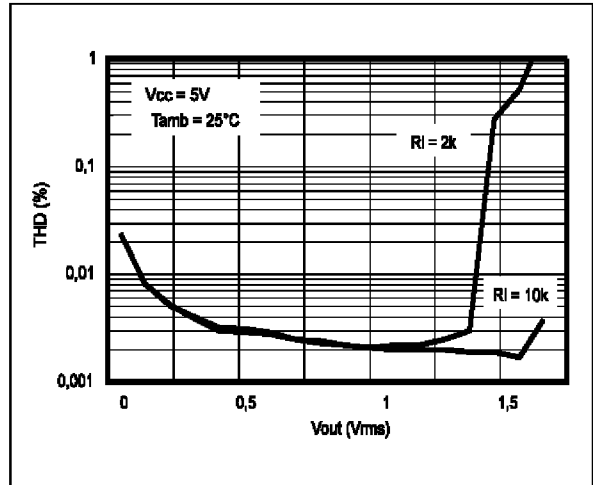
VOLTAGE GAIN & PHASE vs FREQUENCY



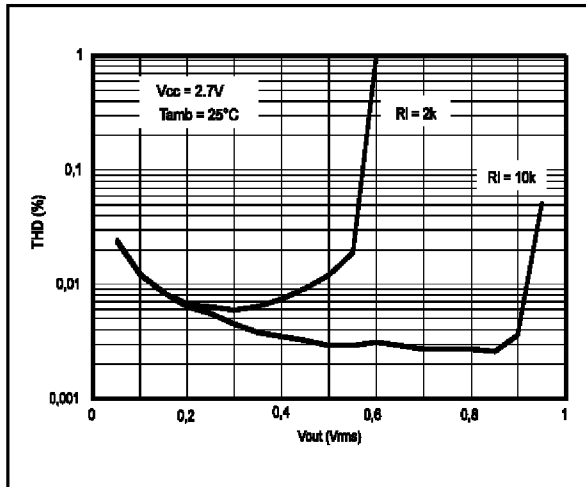
VOLTAGE GAIN & PHASE vs FREQUENCY



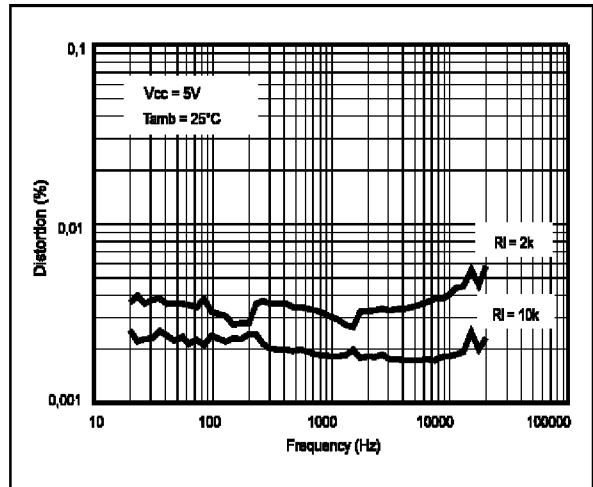
THD vs Vout



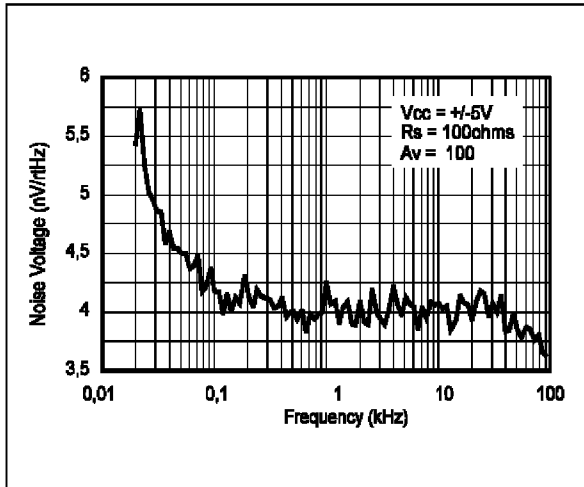
THD vs Vout



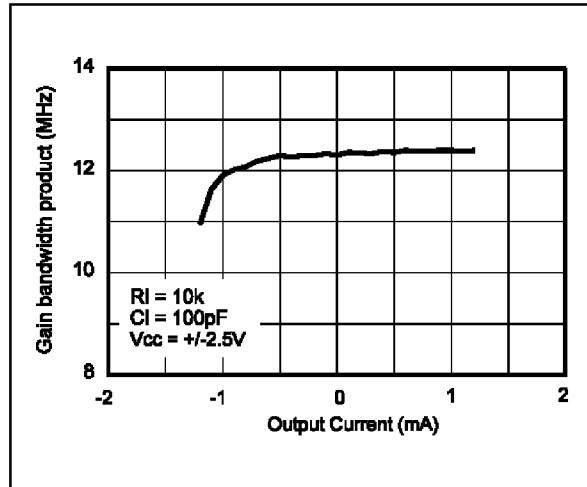
THD vs FREQUENCY



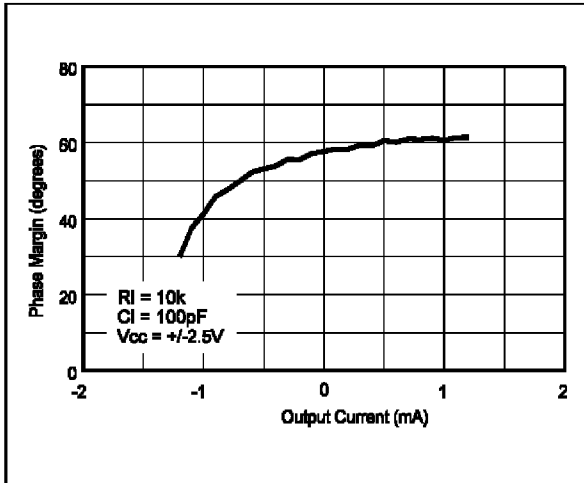
NOISE VOLTAGE vs FREQUENCY



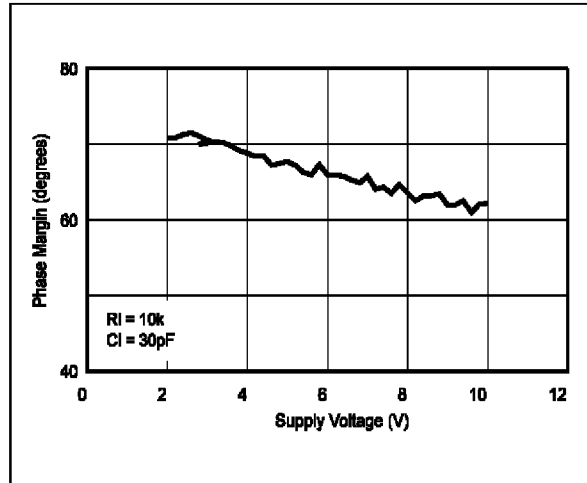
GAIN BANDWIDTH PRODUCT vs Iout



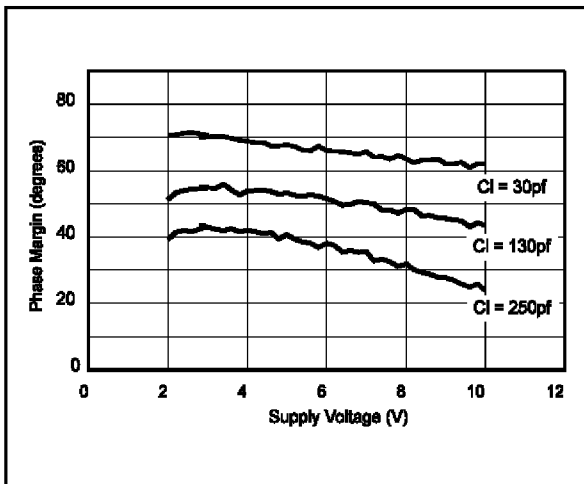
PHASE MARGIN vs Iout



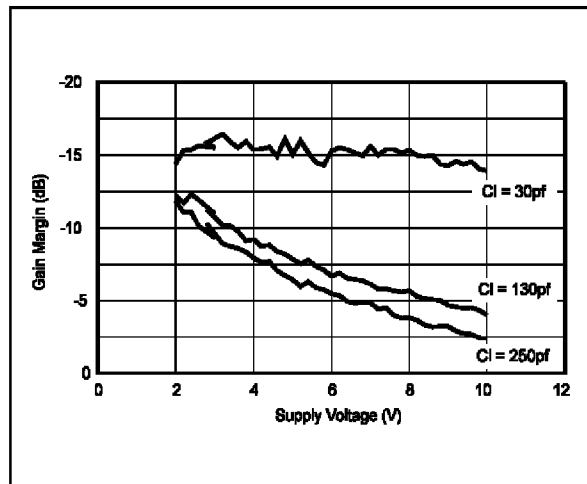
PHASE MARGIN vs VCC



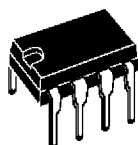
PHASE MARGIN vs VCC



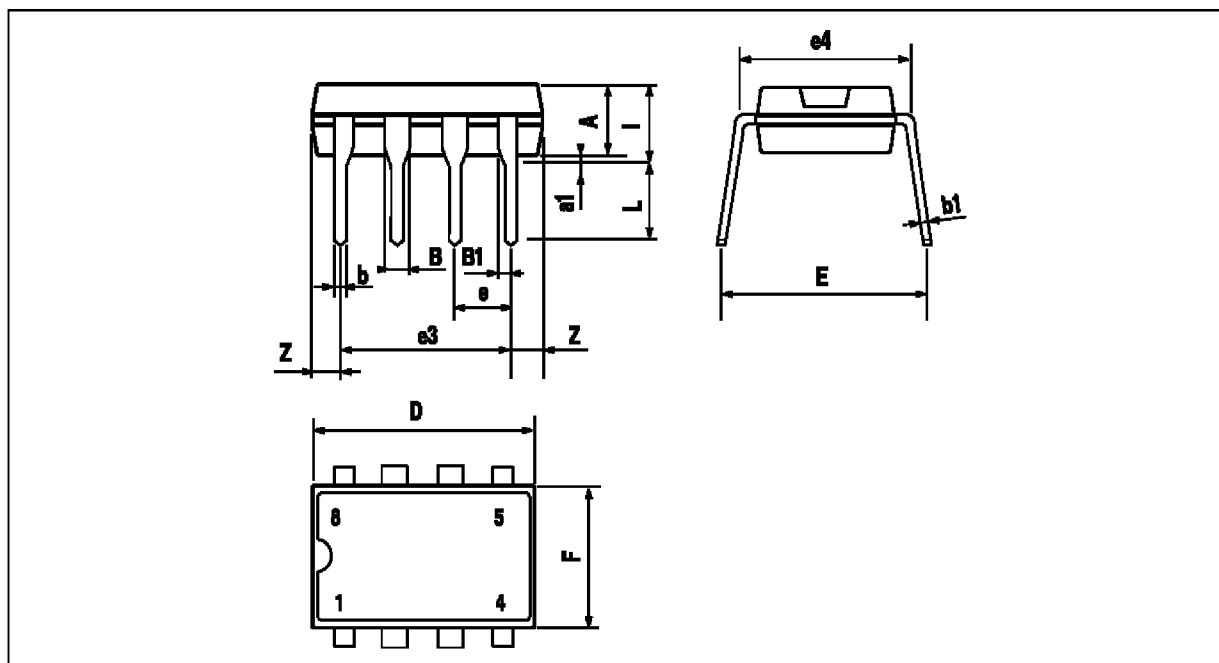
GAIN MARGIN vs VCC



TS972IN

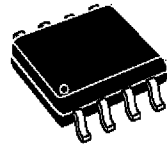


PACKAGE MECHANICAL DATA  
8 PINS - PLASTIC DIP

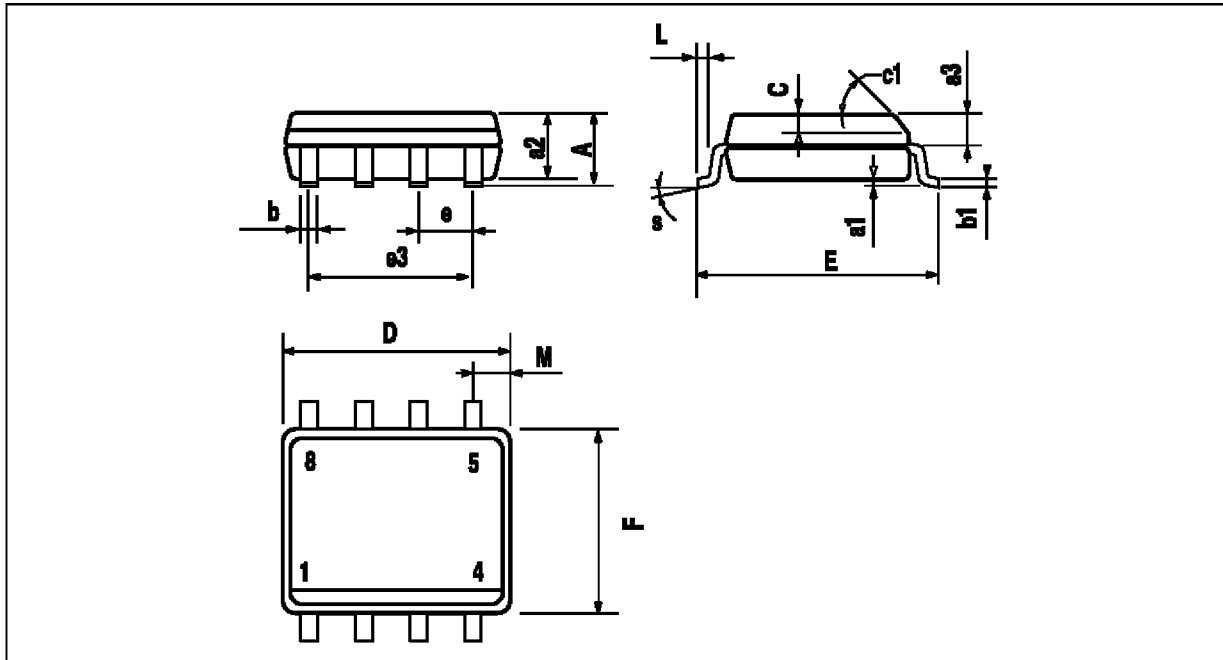


Dimensions	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A		3.32			0.131	
a1	0.51			0.020		
B	1.15		1.65	0.045		0.065
b	0.356		0.55	0.014		0.022
b1	0.204		0.304	0.008		0.012
D			10.92			0.430
E	7.95		9.75	0.313		0.384
e		2.54			0.100	
e3		7.62			0.300	

TS971ID - TS972ID



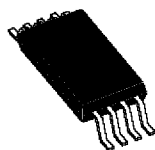
**PACKAGE MECHANICAL DATA**  
8 PINS - PLASTIC MICROPACKAGE (SO)



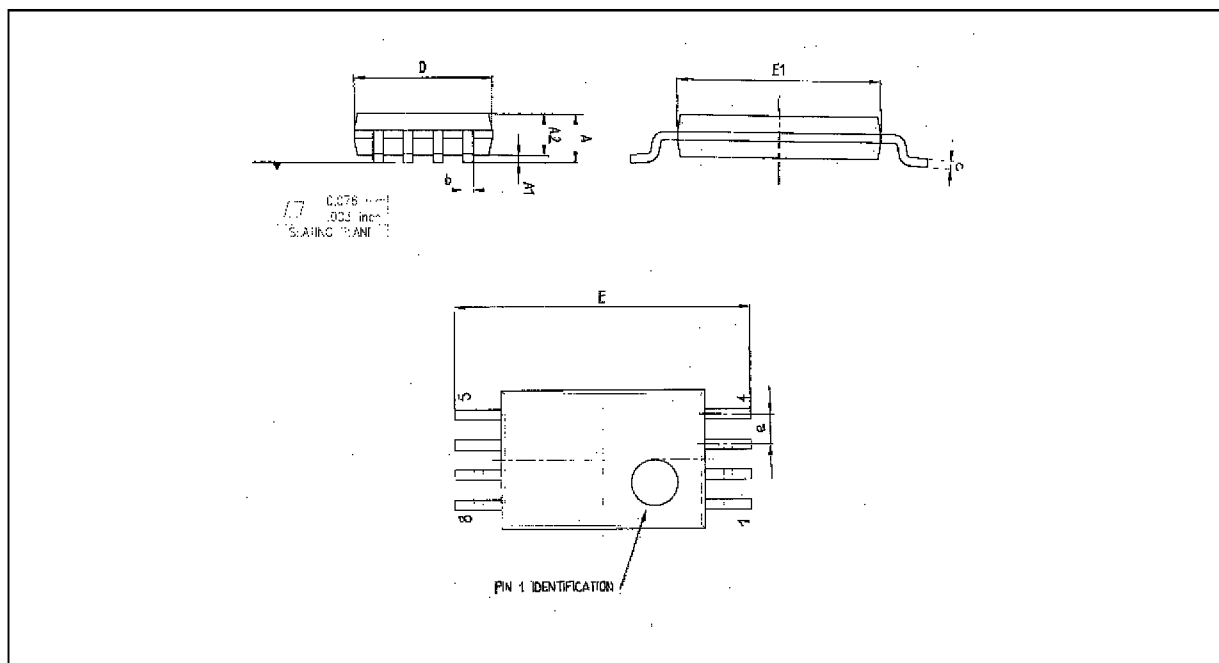
Dimensions	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.75			0.069
a1*	0.1		0.25	0.004		0.010
a2			1.65			0.065
a3	0.65		0.85	0.026		0.033
b	0.35		0.48	0.014		0.019
b1	0.19		0.25	0.007		0.010
C	0.25		0.5	0.010		0.020
c1	45° (typ.)					
D	4.8		5.0	0.189		0.197
E	5.8		6.2	0.228		0.244
e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

\* coplanarity between all the leads : 0.1mm

TS972IPT



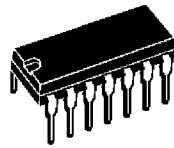
**PACKAGE MECHANICAL DATA**  
8 PINS - THIN SHRINK SMALL OUTLINE PACKAGE (TSSOP)



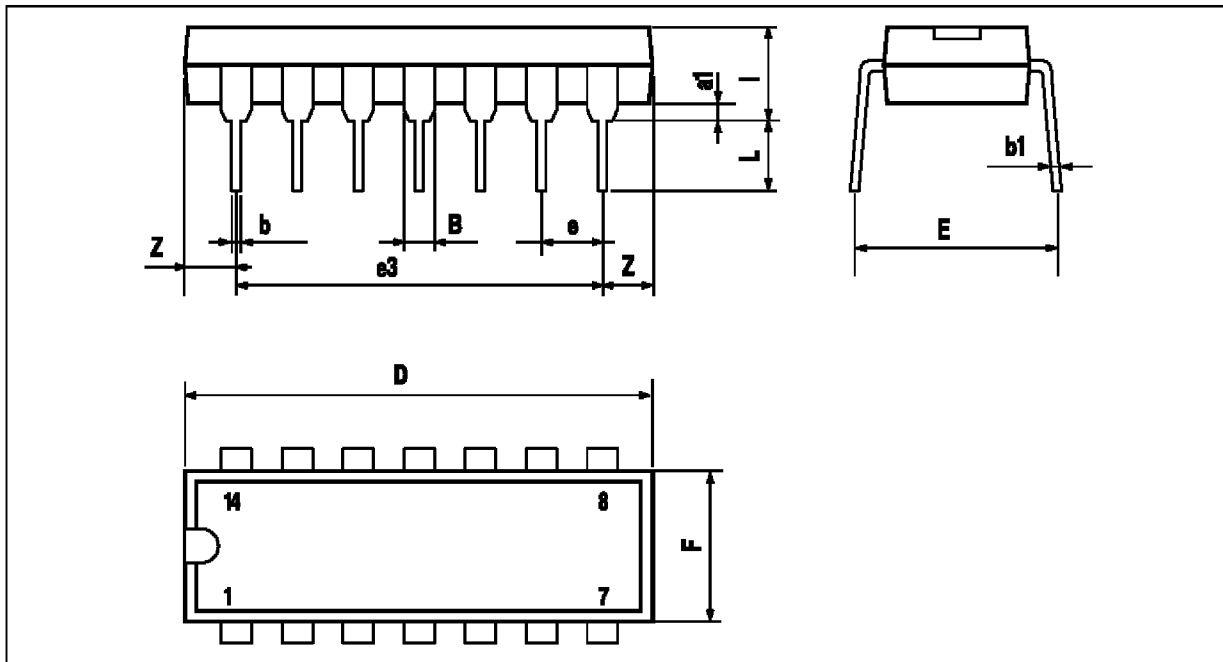
Dim.	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.20			0.05
A1	0.05		0.15	0.01		0.006
A2	0.80	1.00	1.05	0.031	0.039	0.041
b	0.19		0.30	0.007		0.15
c	0.09		0.20	0.003		0.012
D	2.90	3.00	3.10	0.114	0.118	0.122
E		6.40			0.252	
E1	4.30	4.40	4.50	0.169	0.173	0.177
e		0.65			0.025	
k	0°		8°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



TS974IN

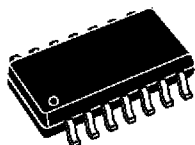


PACKAGE MECHANICAL DATA  
14 PINS - PLASTIC DIP

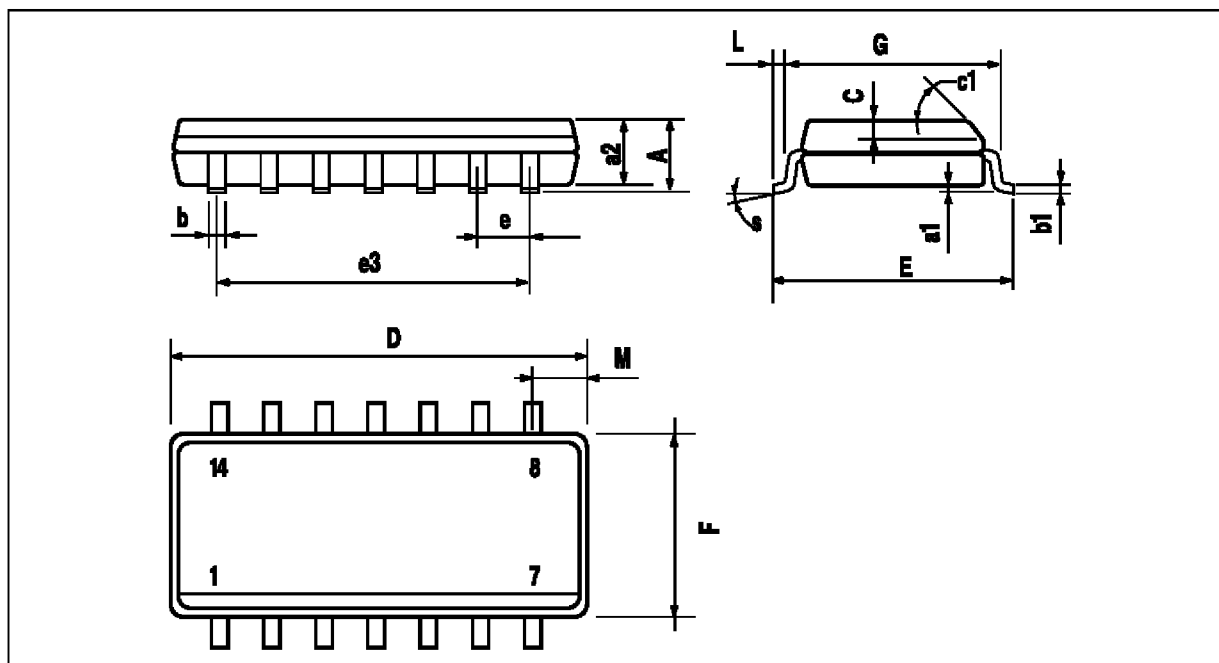


Dim.	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
a1	0.51			0.020		
B	1.39		1.65	0.055		0.065
b		0.5			0.020	
b1		0.25			0.010	
D			20			0.787
E		8.5			0.335	
e		2.54			0.100	
e3		15.24			0.600	

TS974ID

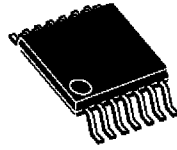


**PACKAGE MECHANICAL DATA**  
14 PINS - PLASTIC MICROPACKAGE (SO)

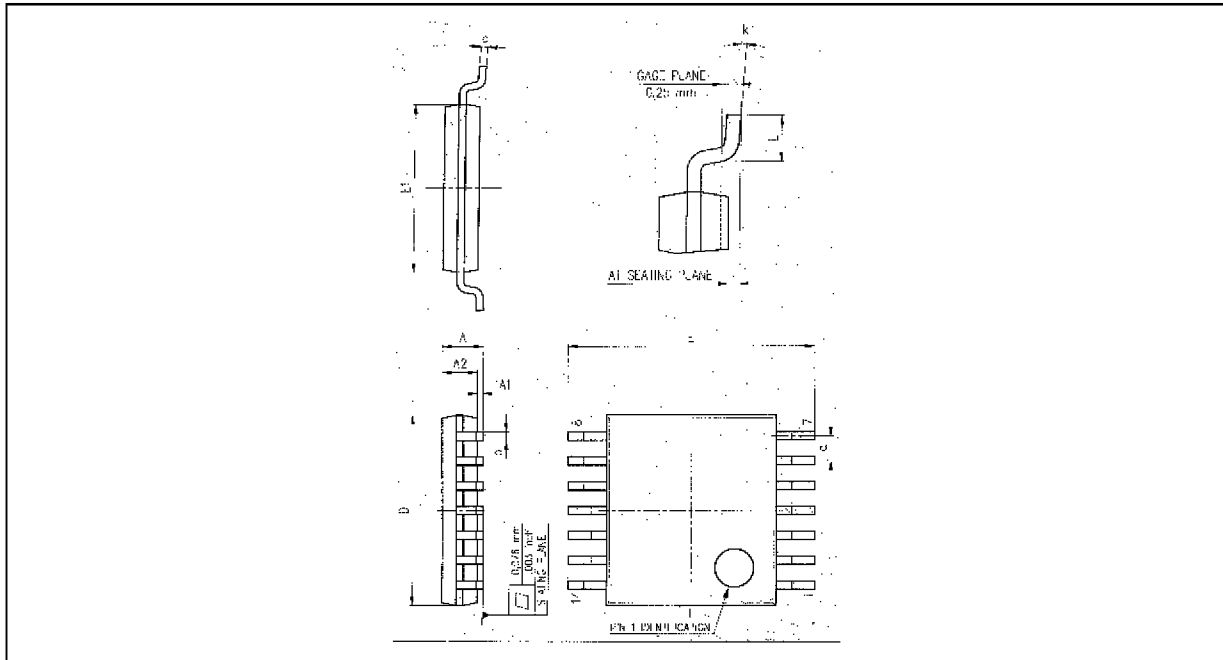


Dim.	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.75			0.069
a1	0.1		0.2	0.004		0.008
a2			1.6			0.063
b	0.35		0.46	0.014		0.018
b1	0.19		0.25	0.007		0.010
C		0.5			0.020	
c1	45° (typ.)					
D	8.55		8.75	0.336		0.334
E	5.8		6.2	0.228		0.244
e		1.27			0.050	
e3		7.62			0.300	
F	3.8		4.0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

TS974IPT

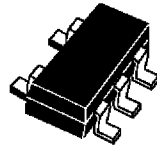


**PACKAGE MECHANICAL DATA**  
14 PINS - THIN SHRINK SMALL OUTLINE PACKAGE (TSSOP)

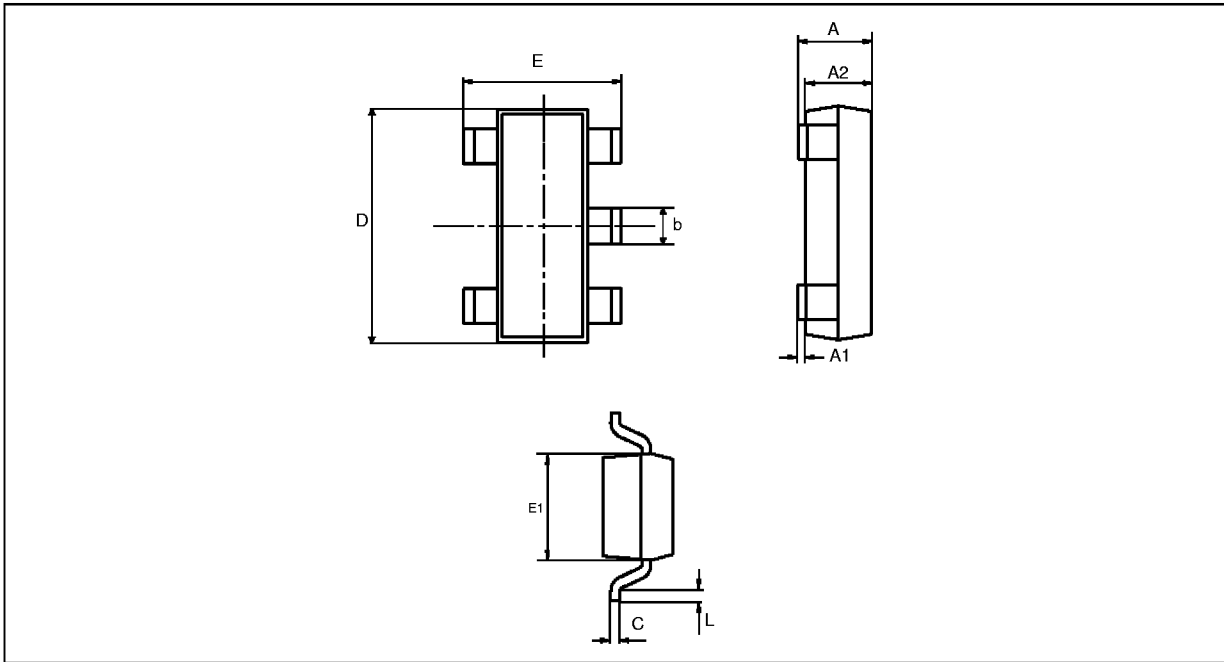


Dim.	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.20			0.05
A1	0.05		0.15	0.01		0.006
A2	0.80	1.00	1.05	0.031	0.039	0.041
b	0.19		0.30	0.007		0.15
c	0.09		0.20	0.003		0.012
D	4.90	5.00	5.10	0.192	0.196	0.20
E		6.40			0.252	
E1	4.30	4.40	4.50	0.169	0.173	0.177
e		0.65			0.025	
k	0°		8°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

TS971ILT



**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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