OUTPUT **RAIL TO RAIL**
VERY LOW NOISE OPERATIONAL AMPLIFIERS

- RAIL TO RAIL **OUTPUT** VOLTAGE SWING **(±2.4V @ V_{CC} = ±2.5V)**
- VERY LOW NOISE LEVEL : **4nV/√Hz**
- ULTRA LOW DISTORTION : **0.003%**
- HIGH DYNAMIC FEATURES **(12MHz, 4V/µs)**
- OPERATING RANGE : **2.7V to 10V**
- ESD PROTECTION **(2kV)**
- LATCH-UP IMMUNITY **(Class A)**
- **AVAILABLE IN SOT23-5 & 3X3 QFN8 MICROPACKAGE**

DESCRIPTION

The TS97x family operational amplifiers is able to operate with voltages as low as ±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 & sensoring
- Professional audio circuits

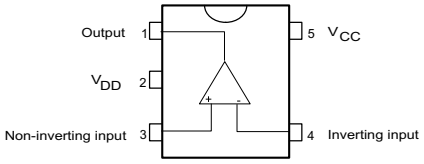
ORDER CODE

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

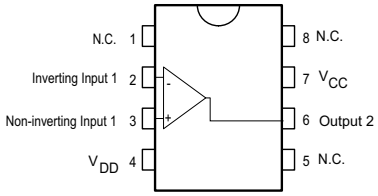
N = Dual in Line Package (DIP)
D = Small Outline Package (SO) - also available in Tape & Reel (DT)
P = Thin Shrink Small Outline Package (TSSOP) - only available In Tape & Reel (PT)
L = Tiny Package (SOT23-5) - only available in Tape & Reel (LT)
Q = QFN only available in Tape & Reel with T suffix,

PIN CONNECTIONS (top view)

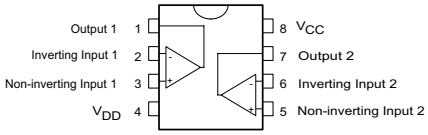
TS971ILT



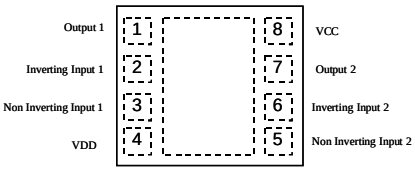
TS971ID-TS971IDT



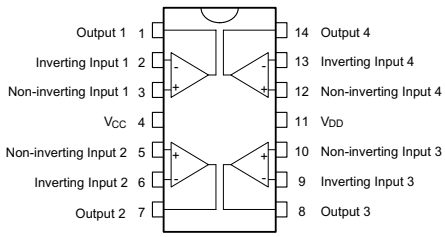
TS972IN-TS972ID-TS972IDT-TS972IPT



TS972IQT : QFN8



TS974IN-TS974ID-TS974IDT-TS974IPT



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CC}	Supply voltage [1]	2.7V to 12	V
V_{id}	Differential Input Voltage [2]	$\pm V_{CC}$	V
V_{in}	Input Voltage [3]	-0.3 to 12.3	V
T_{oper}	Operating Free Air Temperature Range	-40 to +125	°C
Tstg	Storage Temperature Range	-65 to +150	
T_j	Maximum Junction Temperature	150	°C
Rthjc	Thermal Resistance Junction to Case [4] SOT23-5 QFN8 SO8 SO14 TSSOP8 TSSOP14	 81 5 28 22 26 21	°C/W
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 t erminal.
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

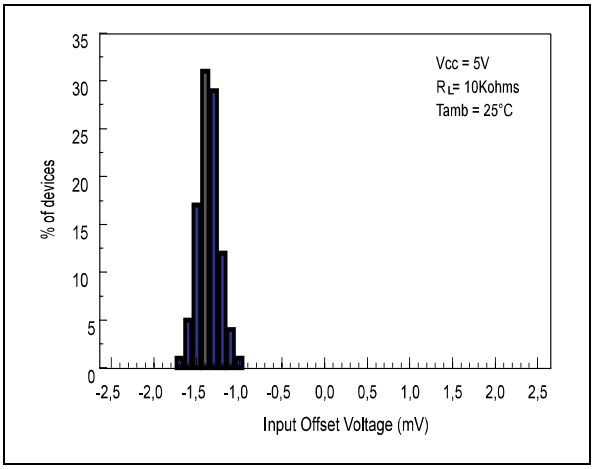
Symbol	Parameter	Value	Unit
V_{CC}	Supply voltage	2.7 to 10	V
V_{icm}	Common Mode Input Voltage Range	V_{DD} +1.15 to V_{CC} -1.15	V

ELECTRICAL CHARACTERISTICS

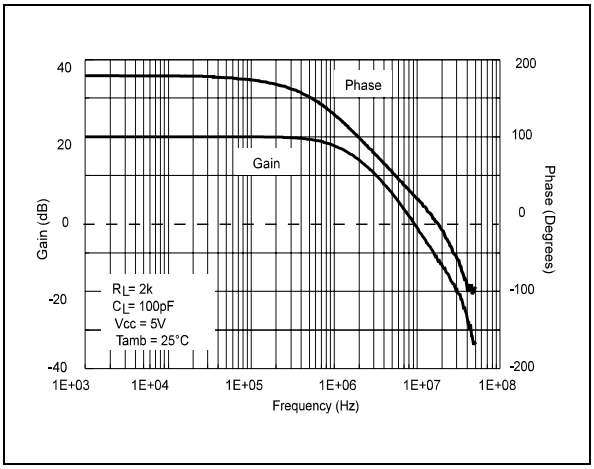
V_{CC} = **+2.5V**, V_{DD} = **-2.5V**, T_{amb} = 25°C (unless otherwise specified)

Symbol	Parameter		Min.	Typ.	Max.	Unit
V_{io}	Input Offset Voltage $T_{min} \le T_{amb} \le T_{max}$			1	5 7	mV
DV_{io}	Input Offset Voltage Drift V_{icm} = 0V, V_o = 0V			5		µV/°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 $T_{min} \le T_{amb} \le T_{max}$			200 200	750 1000	nA
V_{icm}	Common Mode Input Voltage Range		-1.35		1.35	V
CMR	Common Mode Rejection Ratio V_{icm} = ±1.35V		60	85		dB
SVR	Supply Voltage Rejection Ratio Vcc = ±2V to ±3V		60	70		dB
A_{vd}	Large Signal Voltage Gain	R_L = 2kΩ	70	80		dB
V_{OH}	High Level Output Voltage	R_L = 2kΩ	2	2.4		V
V_{OL}	Low Level Output Voltage	R_L = 2kΩ		-2.4	-2	V
I_{source}	Output Source Current			1.5		mA
I_{sink}	Output Sink Current			100		mA
I_{cc}	Supply Current - per amplifier Unity gain - No load			2	2.8	mA
GBP	Gain Bandwidth Product f = 100kHz	R_L = 2kΩ, C_L = 100pF	8.5	12		MHz
SR	Slew Rate A_V = 1, V_{in} = ±1V		2.8	4		V/µs
∅m	Phase Margin at Unit Gain	R_L = 2kΩ, C_L =100pF		60		Degrees
Gm	Gain Margin	R_L = 2kΩ, 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 =10kΩ		0.003		%

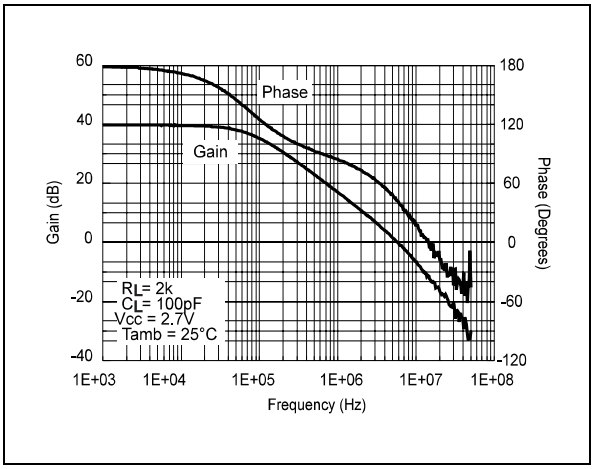
INPUT OFFSET VOLTAGE DISTRIBUTION



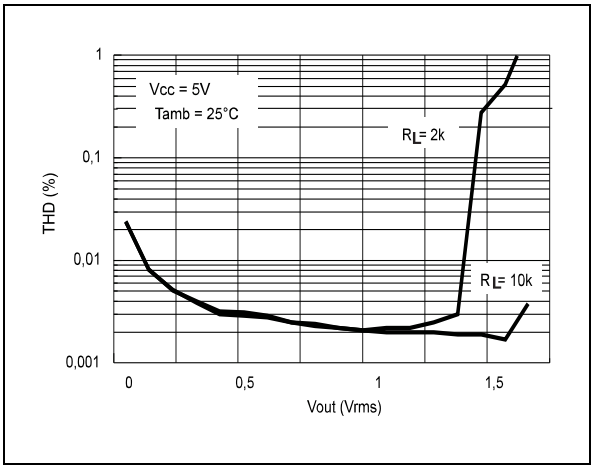
VOLTAGE GAIN & PHASE vs FREQUENCY



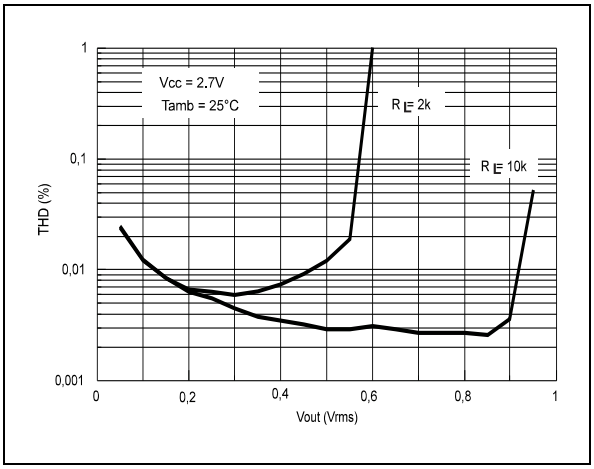
VOLTAGE GAIN & PHASE vs FREQUENCY



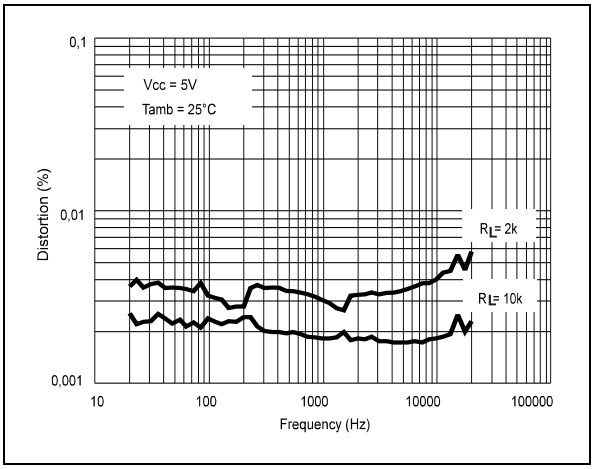
THD vs V_{out}



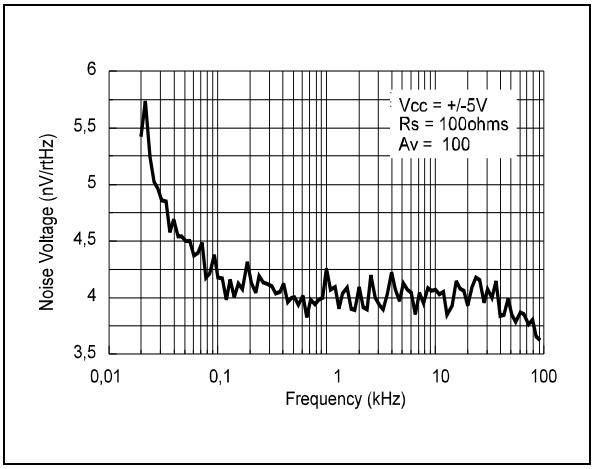
THD vs V_{out}



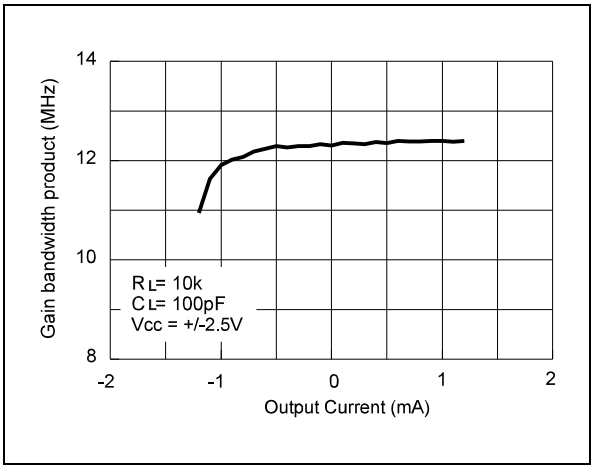
THD vs FREQUENCY



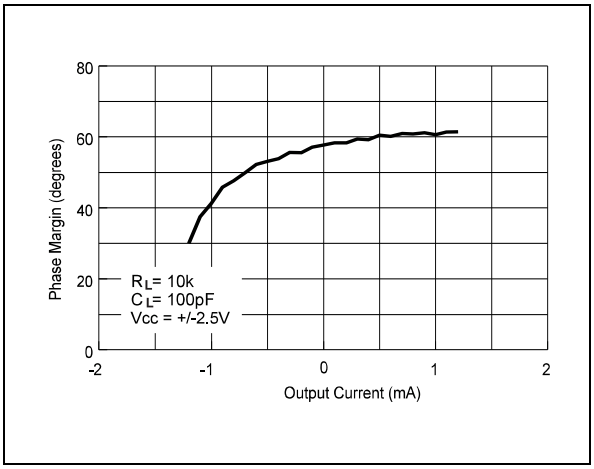
NOISE VOLTAGE vs FREQUENCY



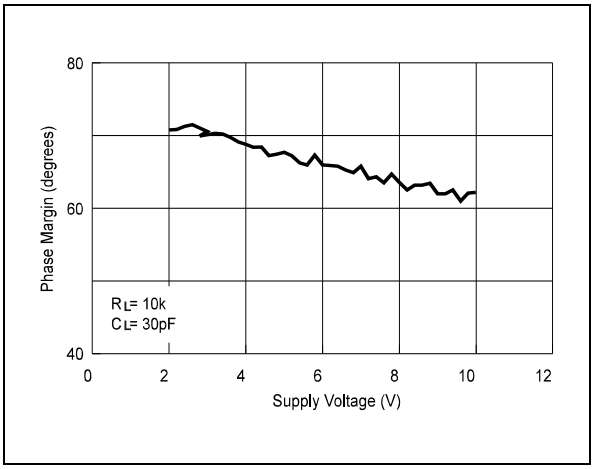
GAIN BANDWITH PRODUCT vs I_{out}



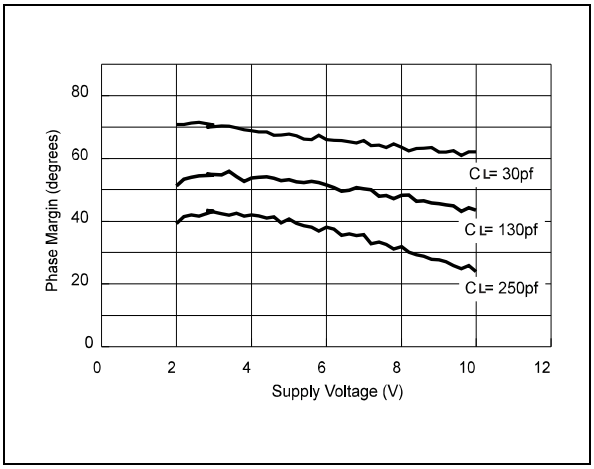
PHASE MARGIN vs I_{out}



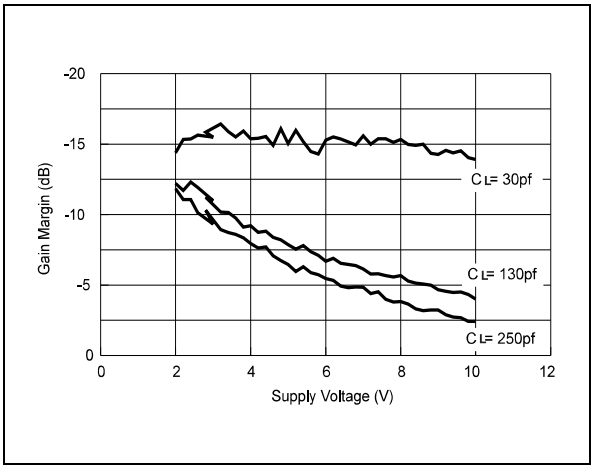
PHASE MARGIN vs V_{cc}



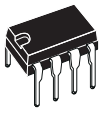
PHASE MARGIN vs V_{cc}



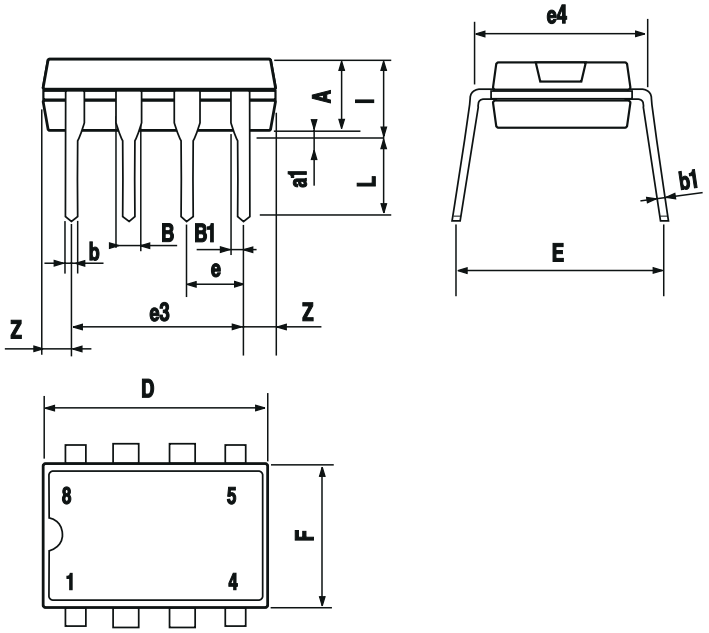
GAIN MARGIN vs V_{cc}



TS972IN

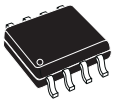


PACKAGE MECHANICAL DATA
8 PINS - PLASTIC PACKAGE



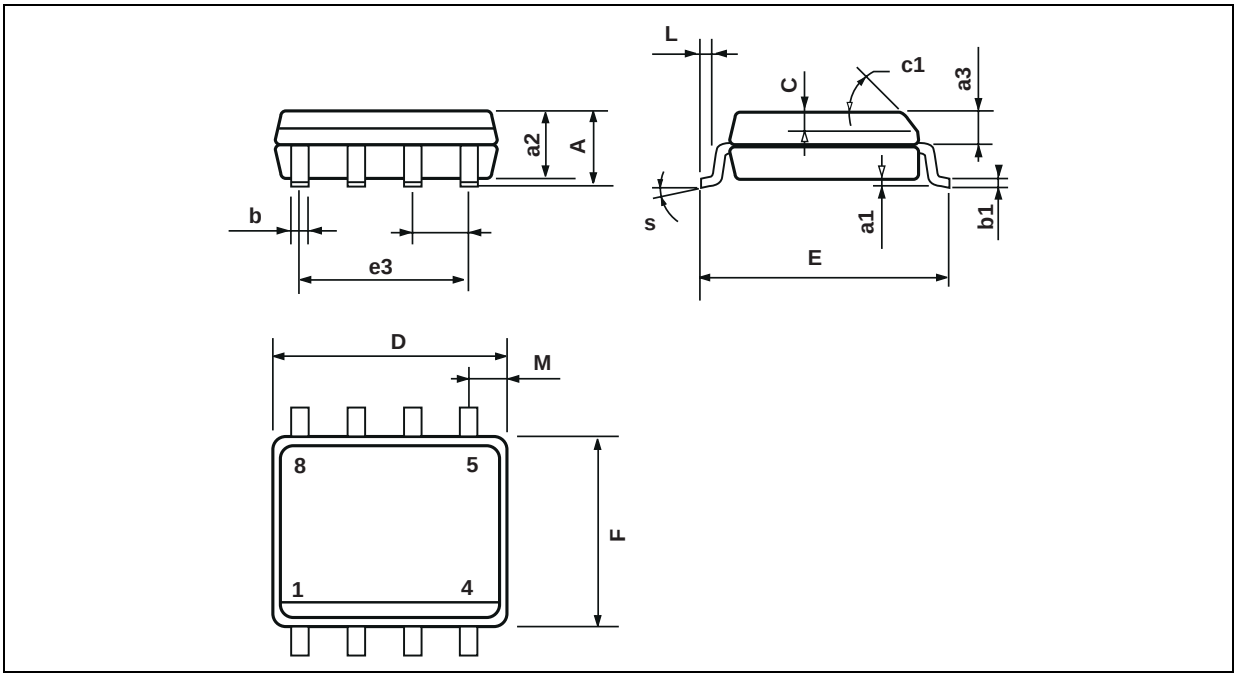
Dim.	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A		3.32			0.131	
a1	0.51			0.020		
B	1.15		1.65	0.045		0.065
b	0.356		0.55	0.014		0.022
b1	0.204		0.304	0.008		0.012
D			10.92			0.430
E	7.95		9.75	0.313		0.384
e		2.54			0.100	
e3		7.62			0.300	
e4		7.62			0.300	
F			6.6			0260
i			5.08			0.200
L	3.18		3.81	0.125		0.150
Z			1.52			0.060

TS971ID-TS972ID



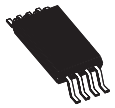
PACKAGE MECHANICAL DATA

8 PINS - PLASTIC MICROPACKAGE (SO)



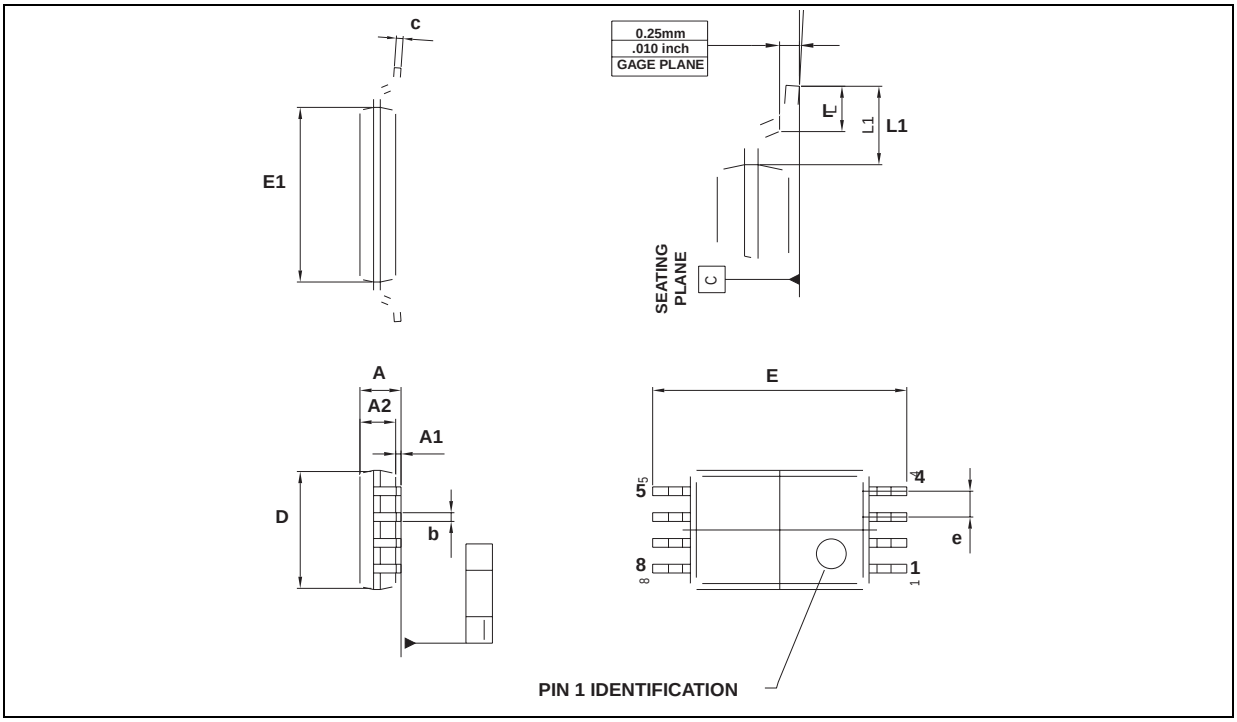
Dim.	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.75			0.069
a1	0.1		0.25	0.004		0.010
a2			1.65			0.065
a3	0.65		0.85	0.026		0.033
b	0.35		0.48	0.014		0.019
b1	0.19		0.25	0.007		0.010
C	0.25		0.5	0.010		0.020
c1	45° (typ.)					
D	4.8		5.0	0.189		0.197
E	5.8		6.2	0.228		0.244
e		1.27	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

TS972IPT



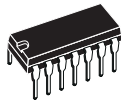
PACKAGE MECHANICAL DATA

8 PINS - THIN SHRINK SMALL OUTLINE PACKAGE

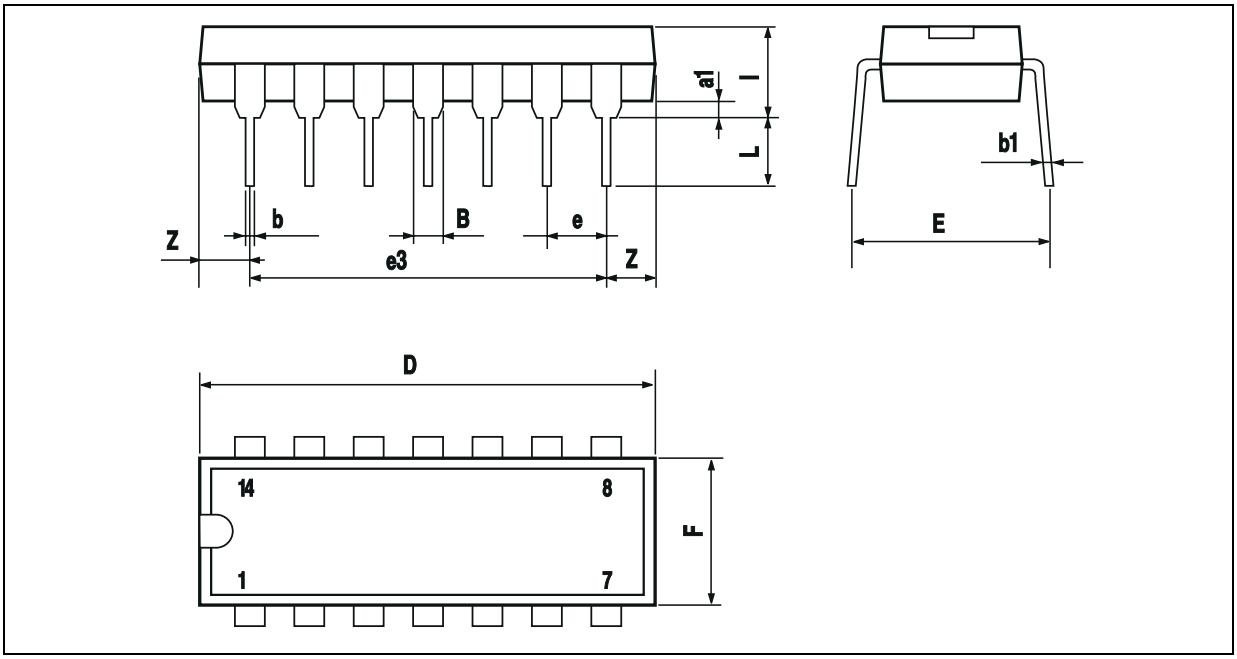


Dim.	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.20			0.05
A1	0.05		0.15	0.01		0.006
A2	0.80	1.00	1.05	0.031	0.039	0.041
b	0.19		0.30	0.007		0.15
c	0.09		0.20	0.003		0.012
D	2.90	3.00	3.10	0.114	0.118	0.122
E		6.40			0.252	
E1	4.30	4.40	4.50	0.169	0.173	0.177
e		0.65			0.025	
k	0°		8°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

TS974IN

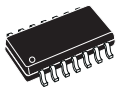


PACKAGE MECHANICAL DATA
14 PINS - PLASTIC PACKAGE



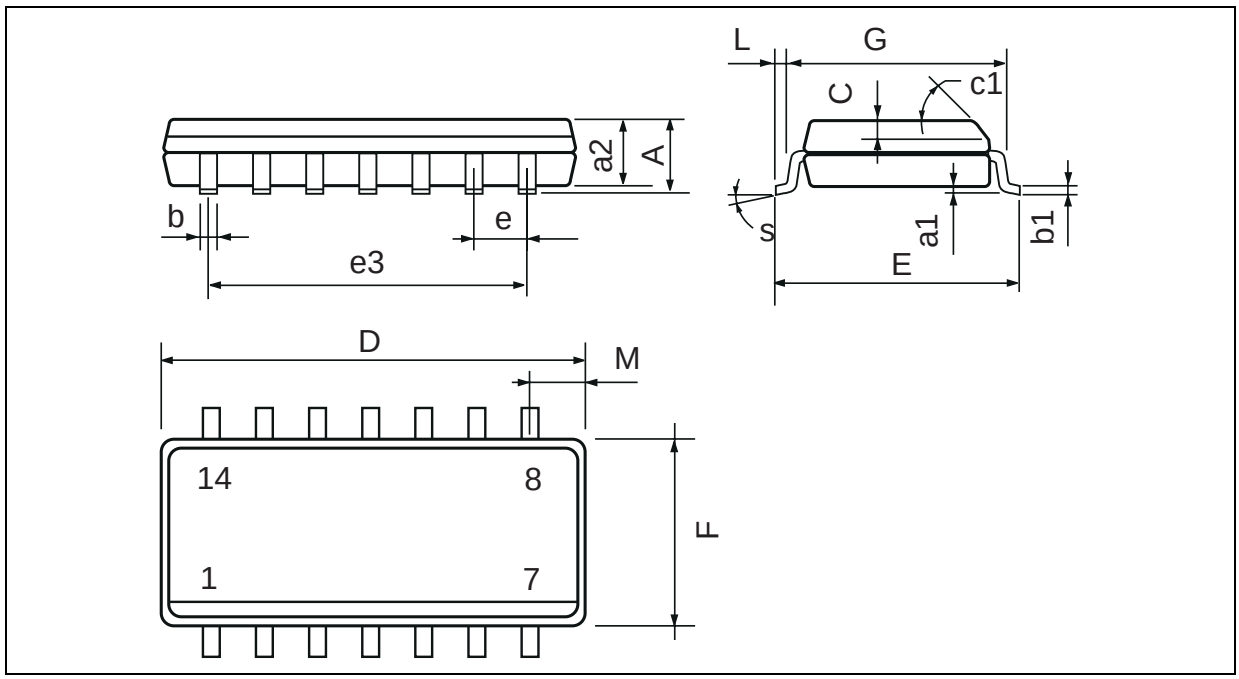
Dim.	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
a1	0.51			0.020		
B	1.39		1.65	0.055		0.065
b		0.5			0.020	
b1		0.25			0.010	
D			20			0.787
E		8.5			0.335	
e		2.54			0.100	
e3		15.24			0.600	
F			7.1			0.280
i			5.1			0.201
L		3.3			0.130	
Z	1.27		2.54	0.050		0.100

TS974ID-TS974IDT



PACKAGE MECHANICAL DATA

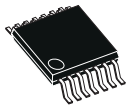
14 PINS - PLASTIC MICROPACKAGE (SO)



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.)					

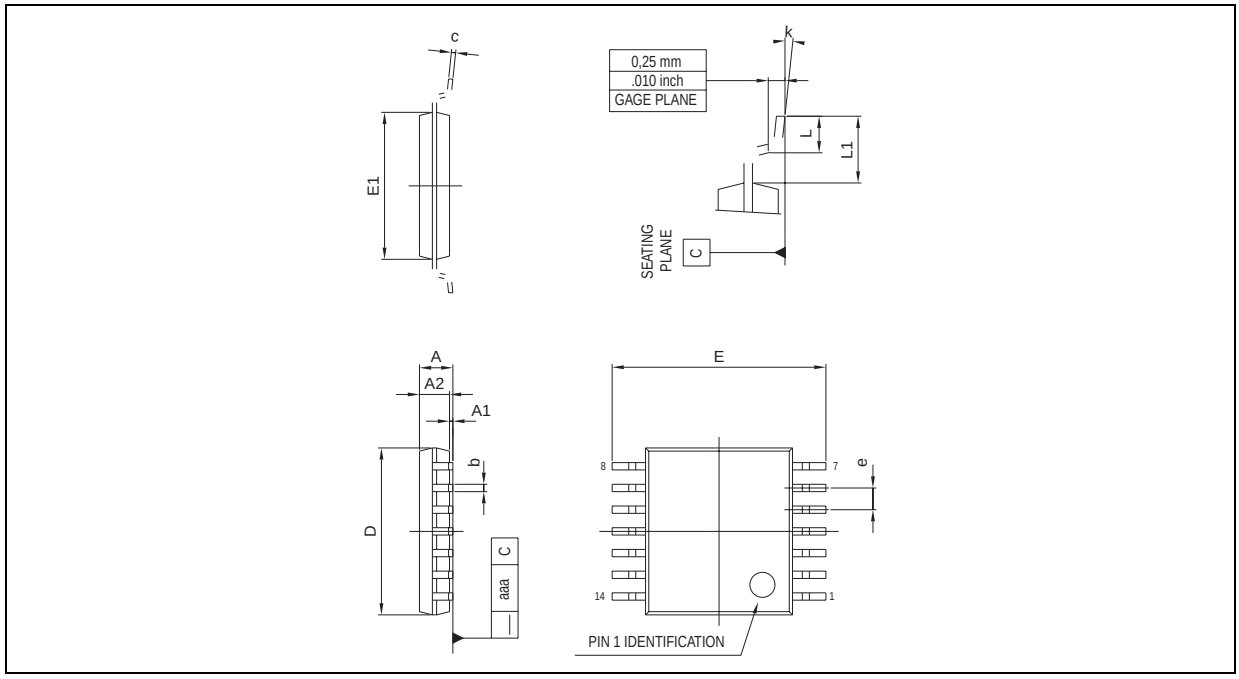
Note : (1) D and F do not include mold flash or protrusions - Mold flash or protrusions shall not exceed 0.15mm (.066 inc) ONLY FOR DATA BOOK.

TS974IPT



PACKAGE MECHANICAL DATA

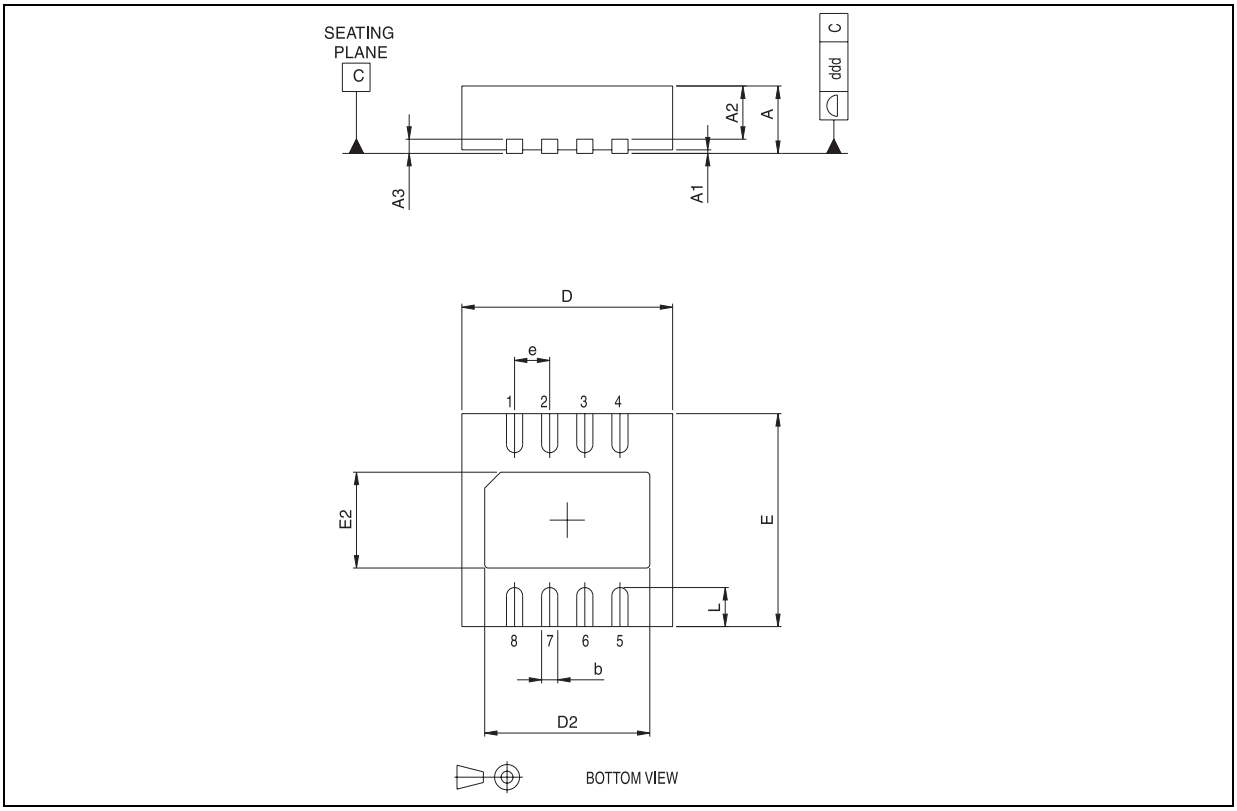
14 PINS - THIN SHRINK SMALL OUTLINE PACKAGE (TSSOP)



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

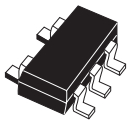
TS972IQ - PACKAGE MECHANICAL DATA

8 CONNECTIONS - Dual Micro Leadframe Package (QFN)



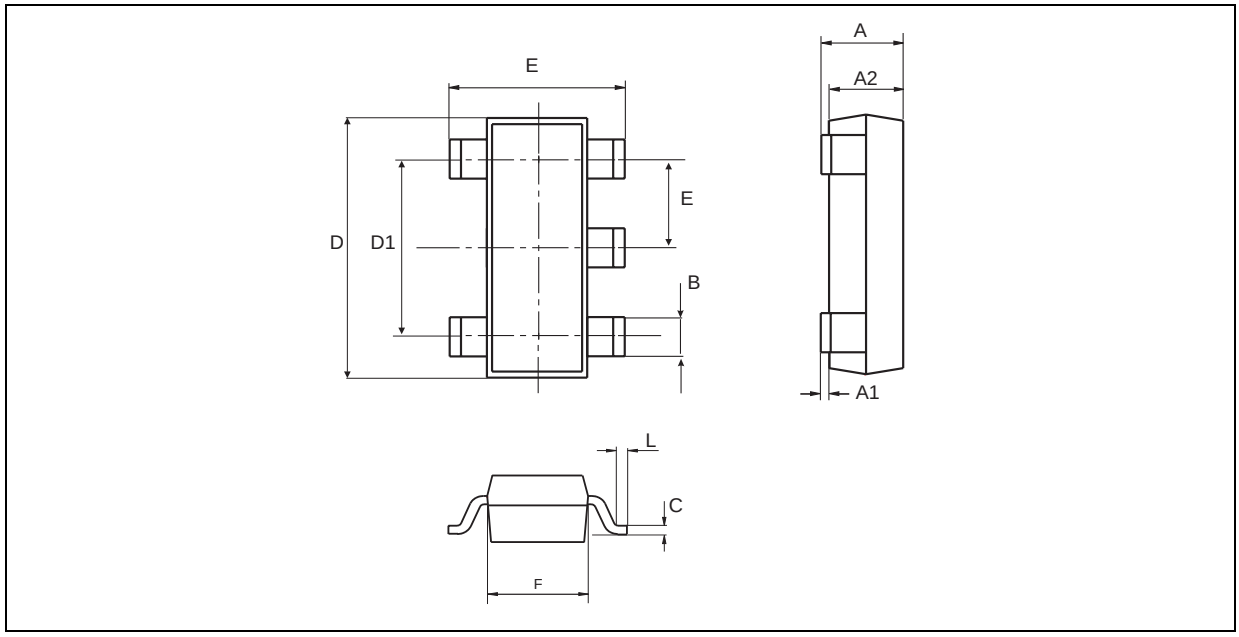
Dimensions	Millimeters		
	Min.	Typ.	Max.
A	0.80	0.90	1.00
A1		0.02	0.05
A2		0.70	
A3		0.20	
b	0.18	0.23	0.30
D		3.00	
D2	2.20	2.35	2.45
E		3.00	
E2	1.20	1.35	1.45
e		0.50	
L	0.45	0.55	0.65
ddd			0.08

TS971ILT



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