TS971-TS972-TS974

Output Rail-to-Rail Very Low Noise Operational Amplifier

- **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.

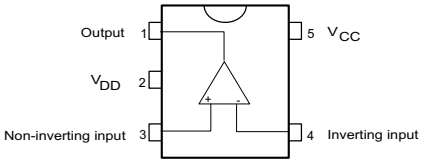
The TS971 is housed in the space-saving 5 pins SOT23 package which simplifies the board design because of the ability to be placed everywhere (outside dimensions are 2.8mm x 2.9mm).

Applications

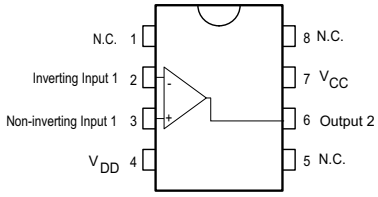
- **Portable equipment (CD players, PDA)**
- **Portable communications (cell phones, pagers)**
- **Instrumentation & sensoring**
- **Professional audio circuits**

Pin Connections (top view)

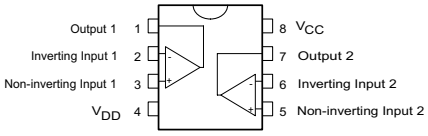
TS971ILT



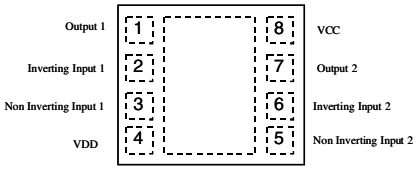
TS971ID-TS971IDT



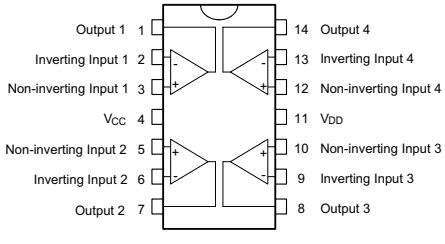
TS972IN-TS972ID-TS972IDT-TS972IPT



TS972IQT: QFN8



TS974IN-TS974ID-TS974IDT-TS974IPT



Order Codes

Part Number	Temperature Range	Package	Packaging	Marking
TS971ID/IDT	-40°C, +125°C	SO	Tube or Tape & Reel	
TS971ILT		SOT23-5L	Tape & Reel	K120
TS972IN		DIP	Tube	
TS972ID/IDT		SO	Tube or Tape & Reel	
TS972IPT		TSSOP (Thin Shrink Outline Package)	Tape & Reel	
TS972IQT		QFN (dual micro lead frame package)	Tape & Reel	
TS974IN		DIP	Tube	
TS974ID/IDT		SO	Tube or Tape & Reel	
TS974IPT		TSSOP (Thin Shrink Outline Package)	Tape & Reel	

1 Absolute Maximum Ratings

Table 1: Key parameters and their absolute maximum ratings

Symbol	Parameter	Value	Unit
V_{CC}	Supply voltage [1]	12	V
V_{id}	Differential Input Voltage [2]	±VCC	V
V_{in}	Input Voltage [3]	Vdd-0.3 to Vcc+0.3	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
R_{thja}	Thermal Resistance Junction to Ambient [4] SOT23-5 QFN8 SO8 SO14 TSSOP8 TSSOP14	 250 50 125 103 120 100	°C/W
ESD	HBM: Human Body Model[5]	2	kV
	MM: Machine Model[6]	200	V
	CDM: Charged Device Model	1.5	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.

5) Human body model, 100pF discharged through a 1.5kΩ resistor into pin of device.

6) Machine model ESD, a 200pF cap is charged to the specified voltage, then discharged directly into the IC with no external series resistor (internal resistor < 5Ω), into pin to pin of device.

Table 2: 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
Topper	Operating Free Air Temperature Range	-40 to +125	°C

2 Electrical Characteristics

Table 3: 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		%

Figure 1: Input offset voltage distribution

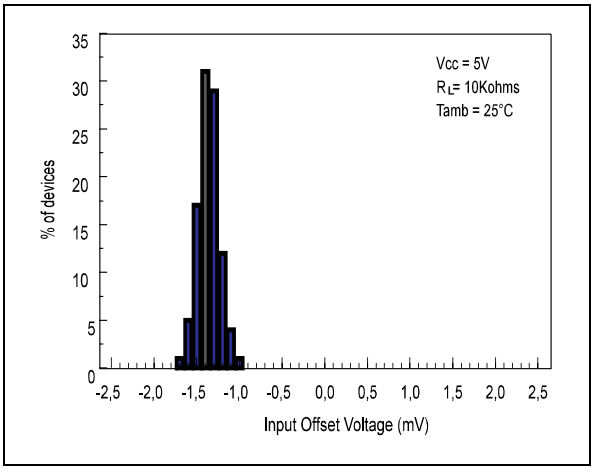


Figure 2: Voltage gain & phase vs. frequency

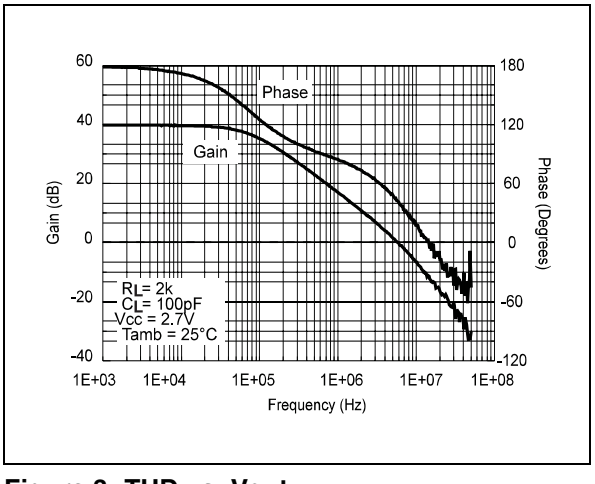


Figure 3: THD vs. Vout

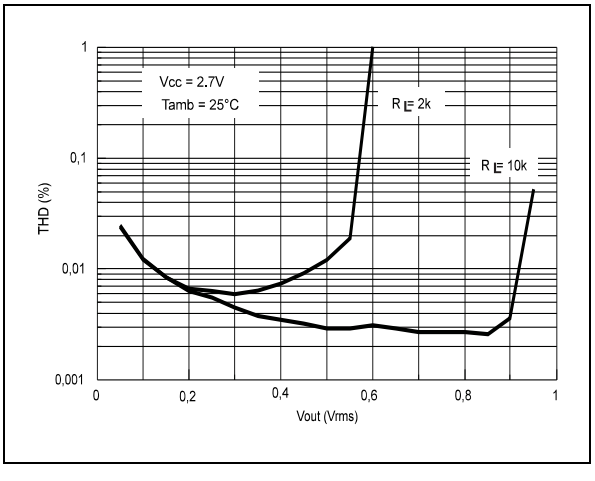


Figure 4: Voltage gain & phase vs. frequency

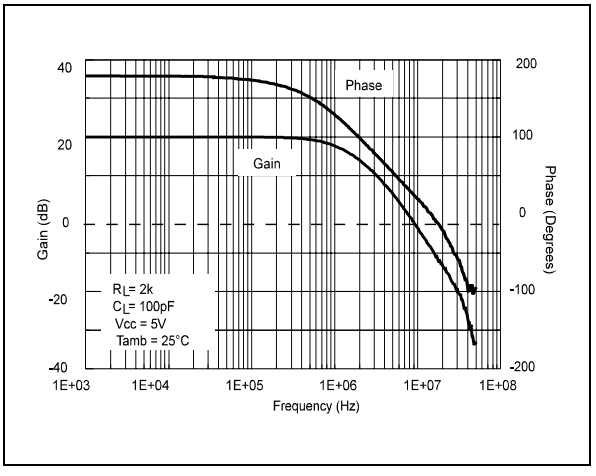


Figure 5: THD vs. Vout

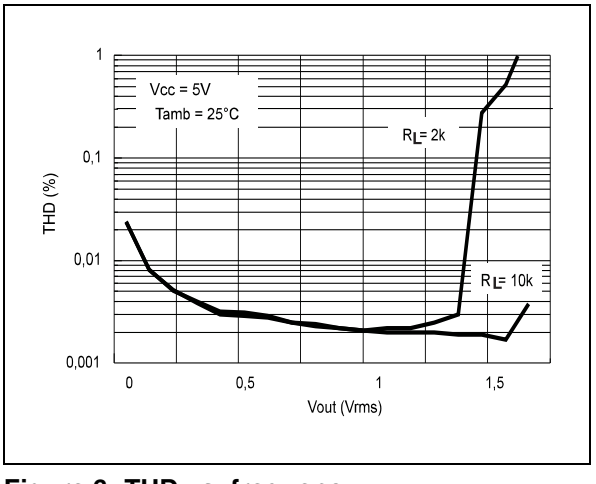


Figure 6: THD vs. frequency

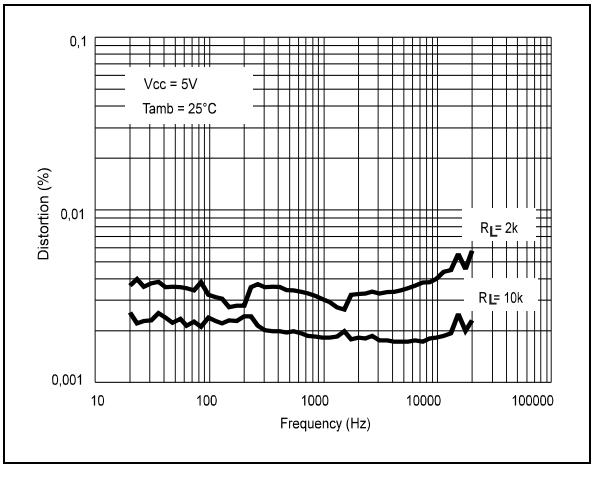


Figure 7: Noise voltage vs. frequency

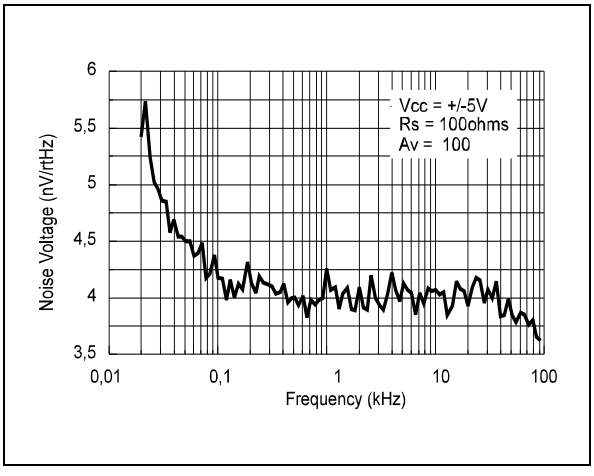


Figure 8: Phase margin vs. Iout

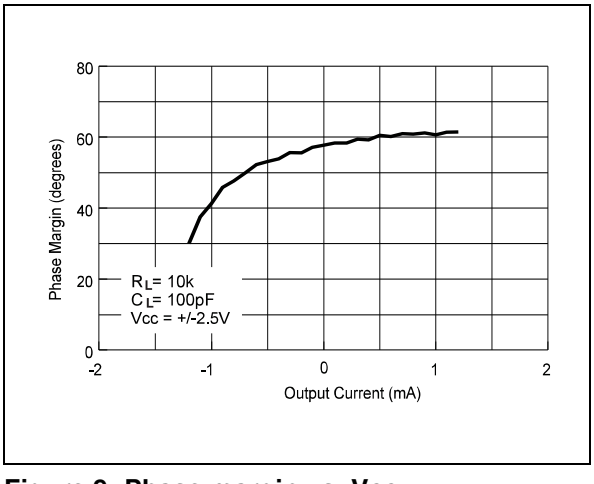


Figure 9: Phase margin vs. Vcc

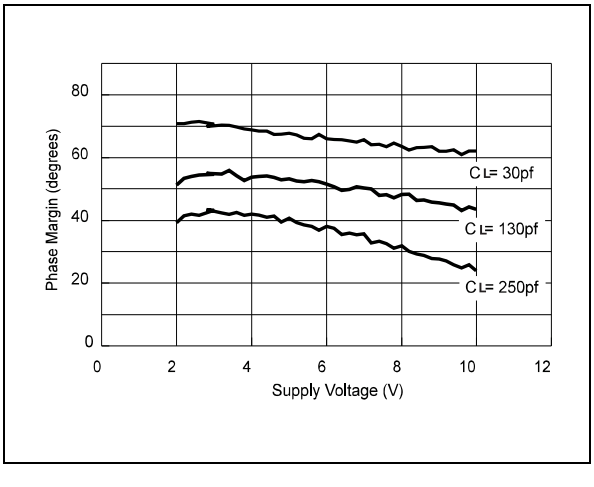


Figure 10: Gain bandwidth product vs. Iout

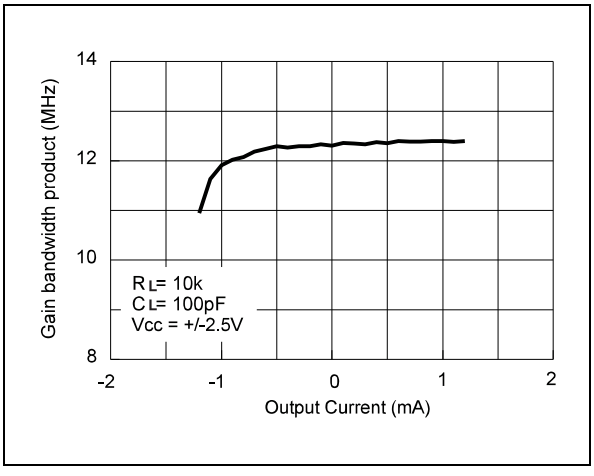


Figure 11: Phase margin vs. Vcc

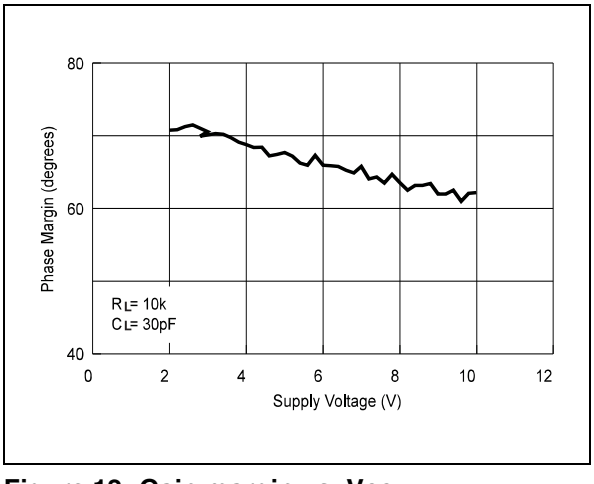
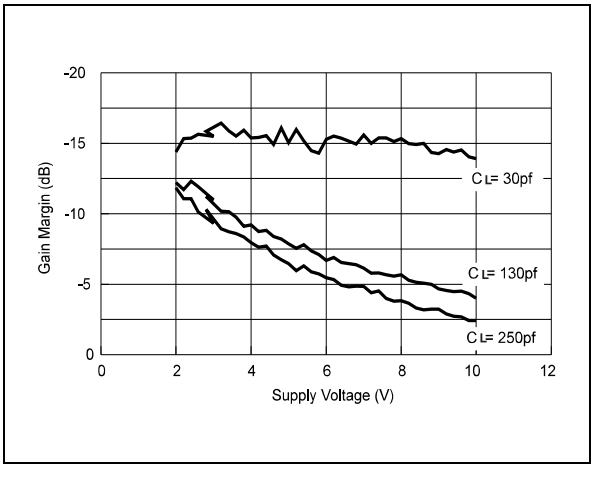


Figure 12: Gain margin vs. Vcc

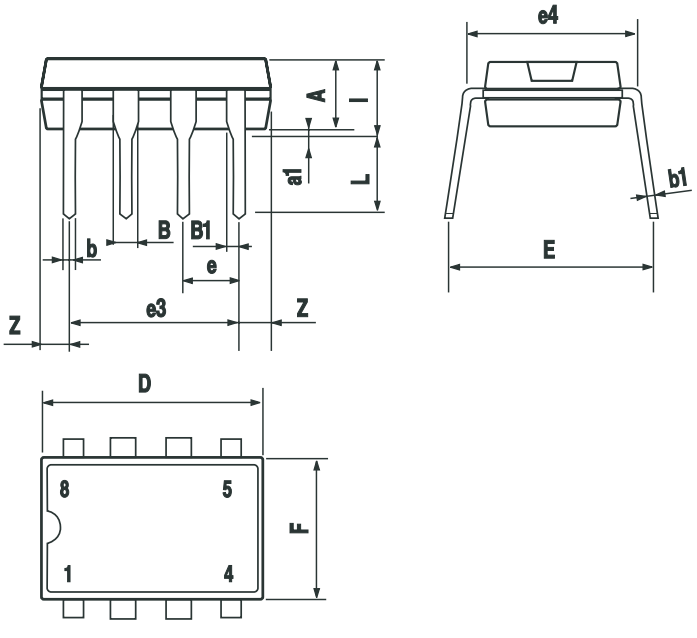


3 Package Mechanical Data

3.1 DIP8 package

Plastic DIP-8 MECHANICAL DATA

DIM.	mm.			inch		
	MIN.	TYP	MAX.	MIN.	TYP.	MAX.
A		3.3			0.130	
a1	0.7			0.028		
B	1.39		1.65	0.055		0.065
B1	0.91		1.04	0.036		0.041
b		0.5			0.020	
b1	0.38		0.5	0.015		0.020
D			9.8			0.386
E		8.8			0.346	
e		2.54			0.100	
e3		7.62			0.300	
e4		7.62			0.300	
F			7.1			0.280
I			4.8			0.189
L		3.3			0.130	
Z	0.44		1.6	0.017		0.063

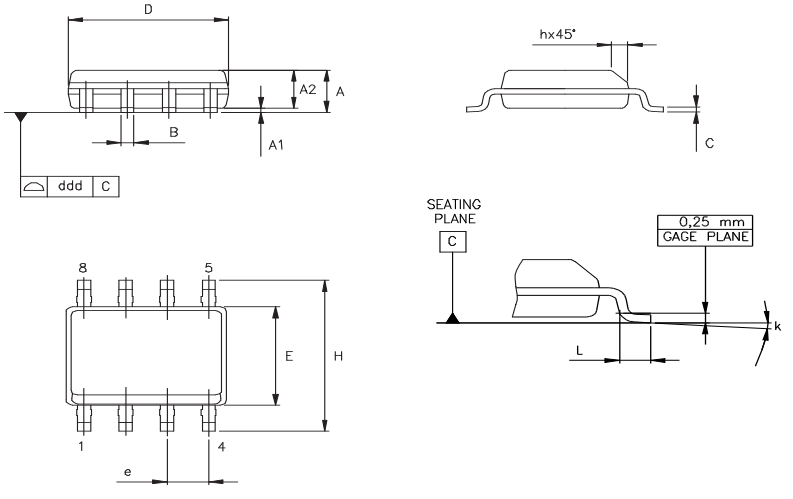


P001F

3.2 SO8 package

SO-8 MECHANICAL DATA

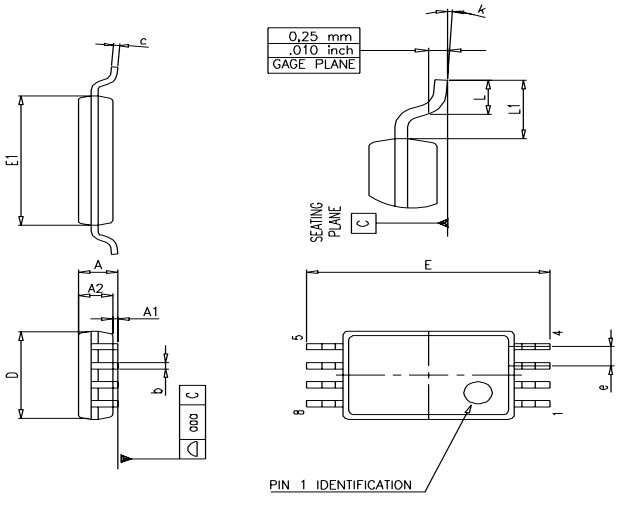
DIM.	mm.			inch		
	MIN.	TYP	MAX.	MIN.	TYP.	MAX.
A	1.35		1.75	0.053		0.069
A1	0.10		0.25	0.04		0.010
A2	1.10		1.65	0.043		0.065
B	0.33		0.51	0.013		0.020
C	0.19		0.25	0.007		0.010
D	4.80		5.00	0.189		0.197
E	3.80		4.00	0.150		0.157
e		1.27			0.050	
H	5.80		6.20	0.228		0.244
h	0.25		0.50	0.010		0.020
L	0.40		1.27	0.016		0.050
k	8° (max.)					
ddd			0.1			0.04



3.3 TSSOP8 package

TSSOP8 MECHANICAL DATA

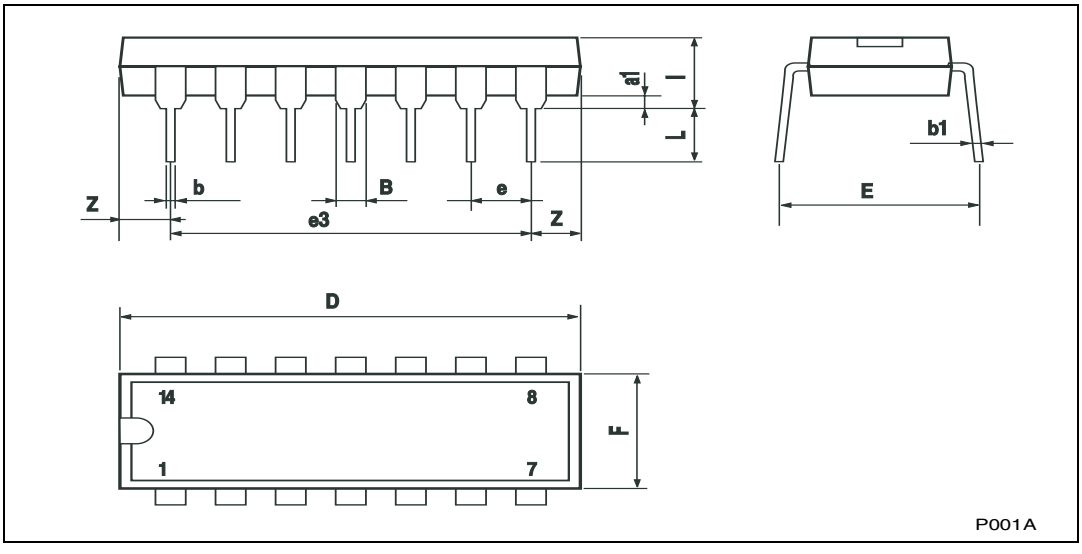
DIM.	mm.			inch		
	MIN.	TYP	MAX.	MIN.	TYP.	MAX.
A			1.2			0.047
A1	0.05		0.15	0.002		0.006
A2	0.80	1.00	1.05	0.031	0.039	0.041
b	0.19		0.30	0.007		0.012
c	0.09		0.20	0.004		0.008
D	2.90	3.00	3.10	0.114	0.118	0.122
E	6.20	6.40	6.60	0.244	0.252	0.260
E1	4.30	4.40	4.50	0.169	0.173	0.177
e		0.65			0.0256	
K	0°		8°	0°		8°
L	0.45	0.60	0.75	0.018	0.024	0.030
L1		1			0.039	



3.4 DIP14 package

Plastic DIP-14 MECHANICAL DATA

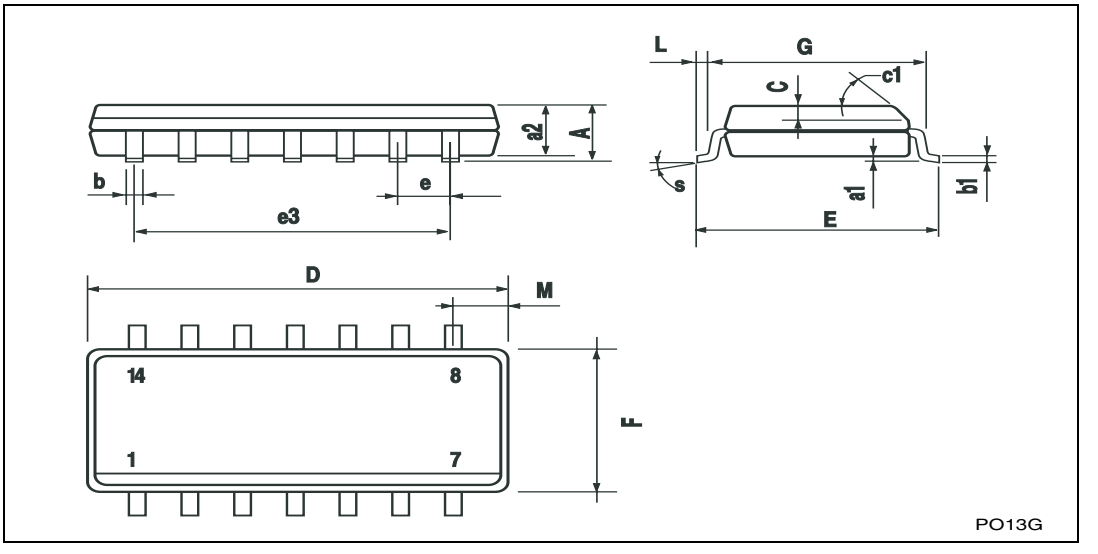
DIM.	mm.			inch		
	MIN.	TYP	MAX.	MIN.	TYP.	MAX.
a1	0.51			0.020		
B	1.39		1.65	0.055		0.065
b		0.5			0.020	
b1		0.25			0.010	
D			20			0.787
E		8.5			0.335	
e		2.54			0.100	
e3		15.24			0.600	
F			7.1			0.280
I			5.1			0.201
L		3.3			0.130	
Z	1.27		2.54	0.050		0.100



3.5 SO14 package

SO-14 MECHANICAL DATA

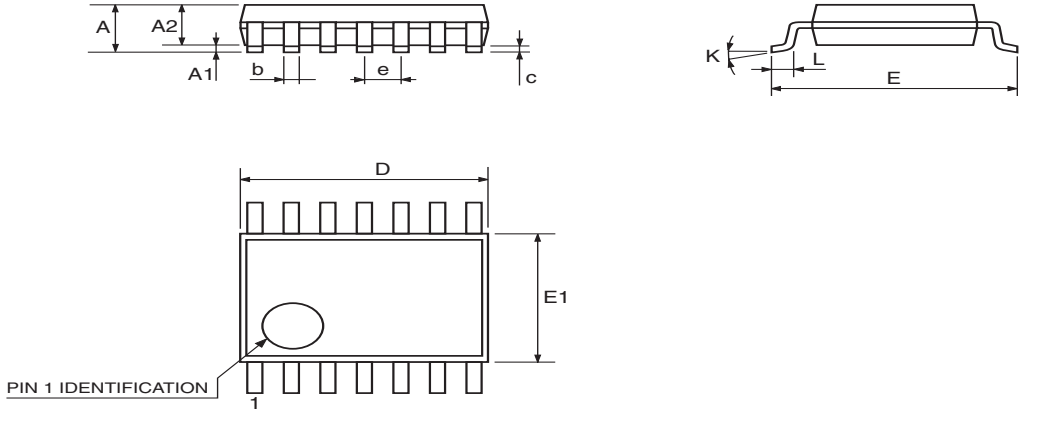
DIM.	mm.			inch		
	MIN.	TYP	MAX.	MIN.	TYP.	MAX.
A			1.75			0.068
a1	0.1		0.2	0.003		0.007
a2			1.65			0.064
b	0.35		0.46	0.013		0.018
b1	0.19		0.25	0.007		0.010
C		0.5			0.019	
c1	45° (typ.)					
D	8.55		8.75	0.336		0.344
E	5.8		6.2	0.228		0.244
e		1.27			0.050	
e3		7.62			0.300	
F	3.8		4.0	0.149		0.157
G	4.6		5.3	0.181		0.208
L	0.5		1.27	0.019		0.050
M			0.68			0.026
S	8° (max.)					



3.6 TSSOP14 package

TSSOP14 MECHANICAL DATA

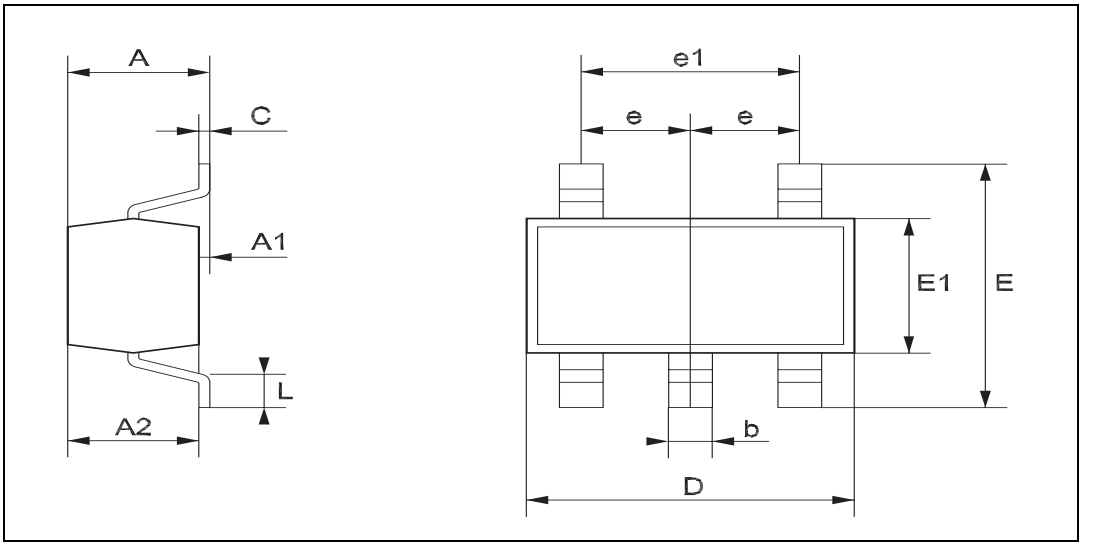
DIM.	mm.			inch		
	MIN.	TYP	MAX.	MIN.	TYP.	MAX.
A			1.2			0.047
A1	0.05		0.15	0.002	0.004	0.006
A2	0.8	1	1.05	0.031	0.039	0.041
b	0.19		0.30	0.007		0.012
c	0.09		0.20	0.004		0.0089
D	4.9	5	5.1	0.193	0.197	0.201
E	6.2	6.4	6.6	0.244	0.252	0.260
E1	4.3	4.4	4.48	0.169	0.173	0.176
e		0.65 BSC			0.0256 BSC	
K	0°		8°	0°		8°
L	0.45	0.60	0.75	0.018	0.024	0.030



3.7 SOT23-5 package

SOT23-5L MECHANICAL DATA

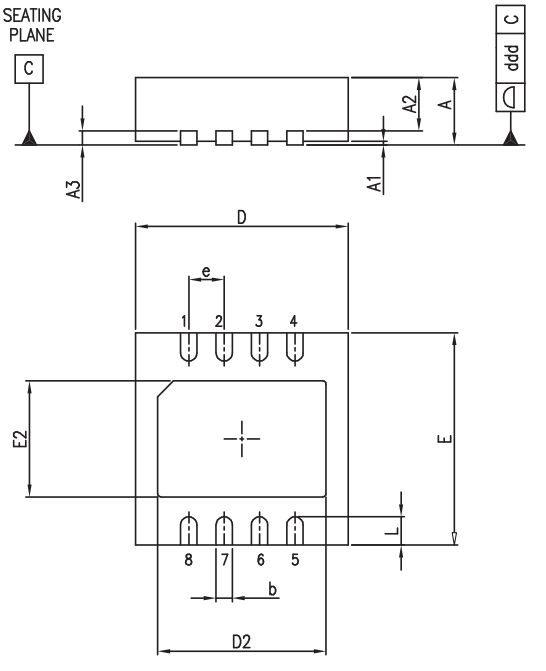
DIM.	mm.			mils		
	MIN.	TYP	MAX.	MIN.	TYP.	MAX.
A	0.90		1.45	35.4		57.1
A1	0.00		0.15	0.0		5.9
A2	0.90		1.30	35.4		51.2
b	0.35		0.50	13.7		19.7
C	0.09		0.20	3.5		7.8
D	2.80		3.00	110.2		118.1
E	2.60		3.00	102.3		118.1
E1	1.50		1.75	59.0		68.8
e		0.95			37.4	
e1		1.9			74.8	
L	0.35		0.55	13.7		21.6



3.8 DFN8 package

DFN8 (3x3) MECHANICAL DATA

DIM.	mm.			inch		
	MIN.	TYP	MAX.	MIN.	TYP.	MAX.
A	0.80	0.90	1.00	31.5	35.4	39.4
A1		0.02	0.05		0.8	2.0
A2		0.70			27.6	
A3		0.20			7.9	
b	0.18	0.23	0.30	7.1	9.1	11.8
D	2.875	3.00	3.125		118.1	
D2	2.23	2.38	2.48	87.8	93.7	97.7
E	2.875	3.00	3.125		118.1	
E2	1.49	1.64	1.74	58.7	64.6	68.5
e		0.50			19.7	
L	0.30	0.40	0.50	11.8	15.7	19.7



4 Revision History

Date	Revision	Description of Changes
Nov. 2002	1	First Release
May 2005	3	Modifications on AMR *Table 1 on page 3* (explanation of Vid and Vi limits)