

## Output Rail-to-Rail Micropower Operational Amplifiers

- Rail-to-rail output voltage swing
- Micropower consumption (20 $\mu$ A)
- Single supply operation (2.7V to 10V)
- Low offset (2mV max for TS93xB)
- CMOS inputs
- Ultra low input bias current (1pA)
- ESD protection (2kV)
- Latch-up immunity (class A)
- Available in SOT23-5 micropackage

### Description

The TS93x (single, dual & quad) series are operational amplifiers able to operate with voltage as low as 2.7V and to reach 2.9Vpp of output swing with  $R_L = 100k\Omega$  when supplied @ 3V.

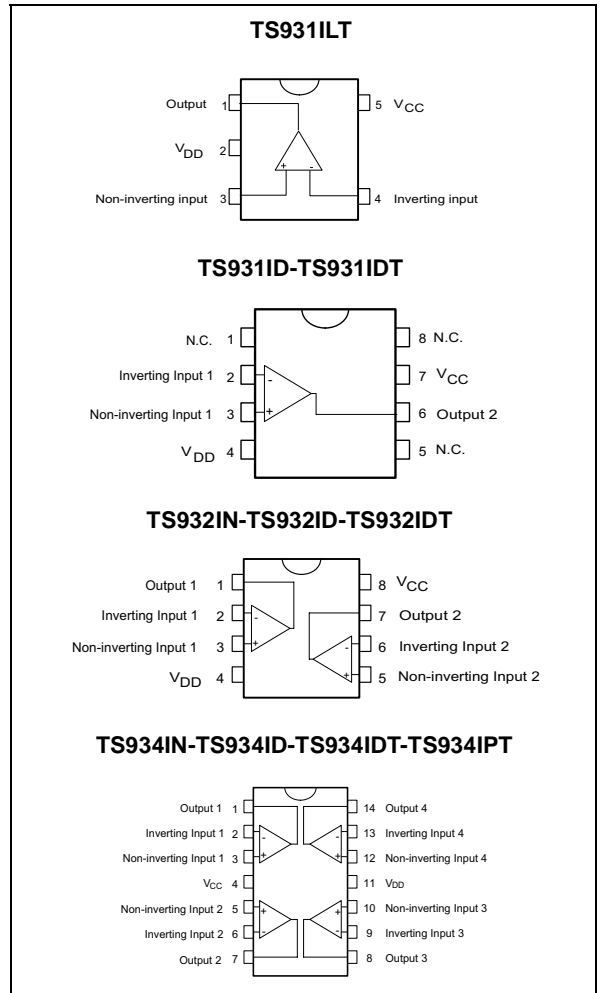
Offering a typical consumption of only 20 $\mu$ A, they are particularly well-suited for battery-powered applications.

Fitting the TS93x onto your board design is very easy because of its space-saving 5-pin SOT23-5 package with outer dimensions of 2.8mm x 2.9mm.

### Applications

- Battery-powered systems
- Portable communication systems
- Alarm, smoke detectors
- Instrumentation & sensing
- PH Meter
- Digital scales

### Pin Connections (top view)



### Order Codes

Part Number	Temperature Range	Package	Packaging	Marking
TS931ID/IDT/AID/AIDT/BID/BIDT	-40°C, +85°C	SO	Tube or Tape & Reel	
TS931ILT/AILT/BILT		SOT23-5L	Tape & Reel	K205 K206 K207
TS932IN/AIN/BIN		DIP	Tube	
TS932ID/IDT/AID/AIDT/BID/BIDT		SO	Tube or Tape & Reel	
TS934IN/AIN/BIN		DIP	Tube	
TS934ID/IDT/AID/AIDT/BIDT/BIDT		SO	Tube or Tape & Reel	
TS934IPT/AIPT/BIPT		TSSOP (Thin Shrink Outline Package)	Tape & Reel	

## 1 Absolute Maximum Ratings

**Table 1: Key parameters and their absolute maximum ratings**

Symbol	Parameter	Value	Unit
VCC	Supply voltage <sup>1</sup>	12	V
V <sub>id</sub>	Differential Input Voltage <sup>2</sup>	±12	V
V <sub>in</sub>	Input Voltage Range <sup>3</sup>	V <sub>dd</sub> -0.3 to V <sub>CC</sub> +0.3	V
T <sub>oper</sub>	Operating Free Air Temperature Range	-40 to + 85	°C
T <sub>std</sub>	Storage Temperature Range	-65 to +150	°C
T <sub>j</sub>	Maximum Junction Temperature	150	°C
R <sub>thja</sub>	Thermal Resistance Junction to Ambient <sup>4</sup>		°C/W
	SOT23-5	250	
	DIP8	85	
	DIP14	66	
	SO8	125	
	SO14	103	
	TSSOP8	120	
	TSSOP14	100	
ESD	HBM: Human Body Model <sup>5</sup>	2	kV
	MM: Machine Model <sup>6</sup>	200	V
	CDM: Charged Device Model	2	kV
	Latch-up Immunity	200	mA
	Soldering Temperature (10sec), leaded version	250	°C

- 1) All voltages values, except differential voltage are with respect to network 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.
- 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
VCC	Supply Voltage	2.7 to 10	V
V <sub>icm</sub>	Common Mode Input Voltage Range	V <sub>dd</sub> - 0.2 to V <sub>CC</sub> - 1.5	V
T <sub>oper</sub>	Operating Free Air Temperature Range	-40 to + 85	°C

## 2 Electrical Characteristics

Tables 3 and 4 give the electrical characteristics at each  $V_{CC}$  value.

**Table 3:  $V_{CC} = +3V$ ,  $V_{dd} = 0V$ ,  $T_{amb} = 25^{\circ}C$  (unless otherwise specified)**

Symbol	Parameter	Min.	Typ.	Max.	Unit
$V_{io}$	Input Offset Voltage TS931/2/4 TS931/2/4A TS931/2/4B			10 5 2	mV
$\Delta V_{io}$	Input Offset Voltage Drift		3		$\mu V/^{\circ}C$
$I_{io}$	Input Offset Current <sup>1</sup>		1	100	$\mu A$
$I_{ib}$	Input Bias Current <sup>1)</sup>		1	150	$\mu A$
CMR	Common Mode Rejection Ratio $0 \leq V_{icm} \leq V_{CC} - 1.7$		85		dB
SVR	Supply Voltage Rejection Ratio <sup>2</sup>		85		dB
$A_{vd}$	Large Signal Voltage Gain $V_O = 2V_{pp}$ $R_L = 1M\Omega$ $R_L = 100k\Omega$		120 106		dB
$V_{OH}$	High Level Output Voltage $V_{ID} = 100mV$ $R_L = 100k\Omega$	2.95			V
$V_{OL}$	Low Level Output Voltage $V_{ID} = -100mV$ $R_L = 100k\Omega$			50	mV
$I_o$	Output Source Current $V_{ID} = 100mV$ , $V_O = V_{DD}$ Output Sink Current $V_{ID} = -100mV$ , $V_O = V_{CC}$		1.5 1.5		mA
$I_{CC}$	Supply Current (per amplifier) $A_{VCL} = 1$ , no load		20	31	$\mu A$
GBP	Gain Bandwidth Product $R_L = 100k\Omega$ , $C_L = 50pF$		100		kHz
SR	Slew Rate $R_L = 100k\Omega$ , $C_L = 50pF$		50		V/ms
$\phi_m$	Phase Margin $C_L = 50pF$		65		Degrees
en	Input Voltage Noise		75		nV/ $\sqrt{Hz}$

1) Maximum values including unavoidable inaccuracies of the industrial test.

2)  $V_{CC}$  has a 0.2V variation.

Table 4:  $V_{CC} = +5V$ ,  $V_{dd} = 0V$ ,  $T_{amb} = 25^{\circ}C$  (unless otherwise specified)

Symbol	Parameter	Min.	Typ.	Max.	Unit
$V_{io}$	Input Offset Voltage TS931/2/4 TS931/2/4A TS931/2/4B			10 5 2	mV
$\Delta V_{io}$	Input Offset Voltage Drift		3		$\mu V/^{\circ}C$
$I_{io}$	Input Offset Current <sup>1</sup>		1	100	pA
$I_{ib}$	Input Bias Current <sup>1)</sup>		1	150	pA
CMR	Common Mode Rejection Ratio $0 \leq V_{icm} \leq V_{CC} - 1.7$		85		dB
SVR	Supply Voltage Rejection Ratio <sup>2</sup>		85		dB
$A_{vd}$	Large Signal Voltage Gain $V_O = 4V_{pp}$ $R_L = 1M\Omega$ $R_L = 100k\Omega$		120 112		dB
$V_{OH}$	High Level Output Voltage $V_{ID} = 100mV$ $R_L = 100k\Omega$	4.95			V
$V_{OL}$	Low Level Output Voltage $V_{ID} = -100mV$ $R_L = 100k\Omega$			50	mV
$I_o$	Output Source Current $V_{ID} = 100mV$ , $V_O = V_{DD}$ Output Sink Current $V_{ID} = -100mV$ , $V_O = V_{CC}$		5 5		mA
$I_{CC}$	Supply Current (per amplifier) $A_{VCL} = 1$ , no load		20	33	$\mu A$
GBP	Gain Bandwidth Product $R_L = 100K\Omega$ , $C_L = 50pF$		100		kHz
SR	Slew Rate $R_L = 100K\Omega$ , $C_L = 50pF$		50		V/ms
$\phi_m$	Phase Margin $C_L = 50pF$		65		Degrees
en	Input Voltage Noise		76		nV/ $\sqrt{Hz}$

1) Maximum values including unavoidable inaccuracies of the industrial test.

2)  $V_{CC}$  has a 0.2V variation.

Figure 1:

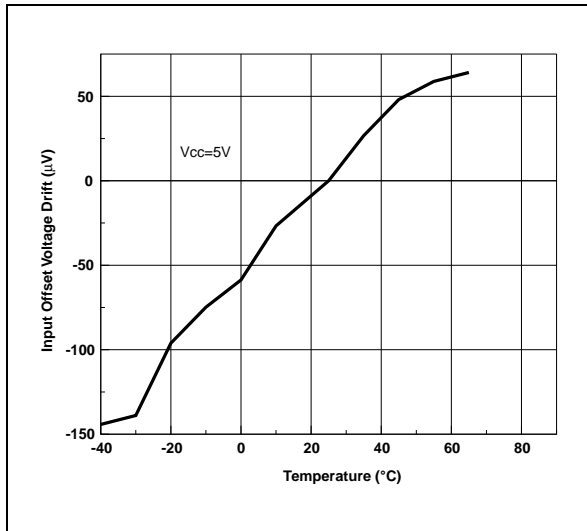


Figure 4:

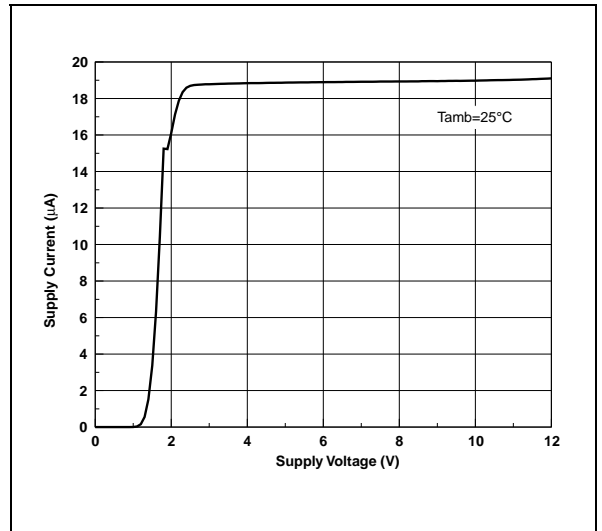


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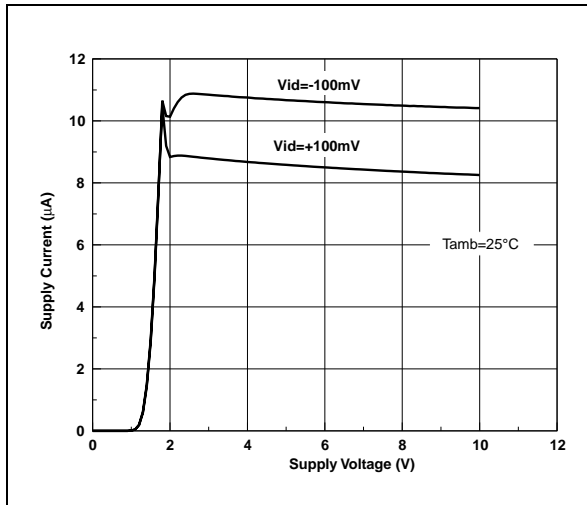


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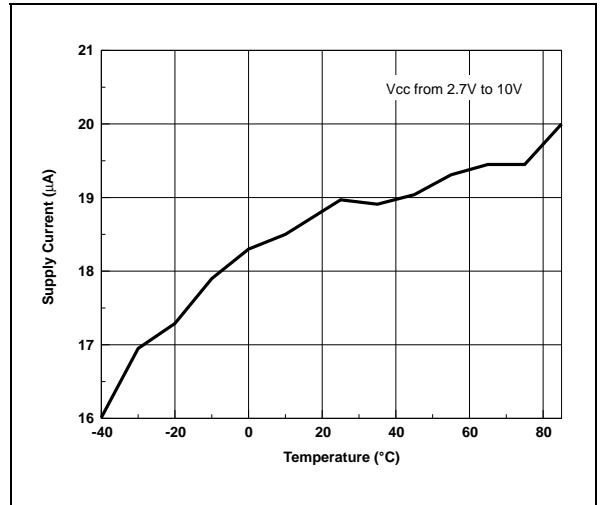


Figure 3:

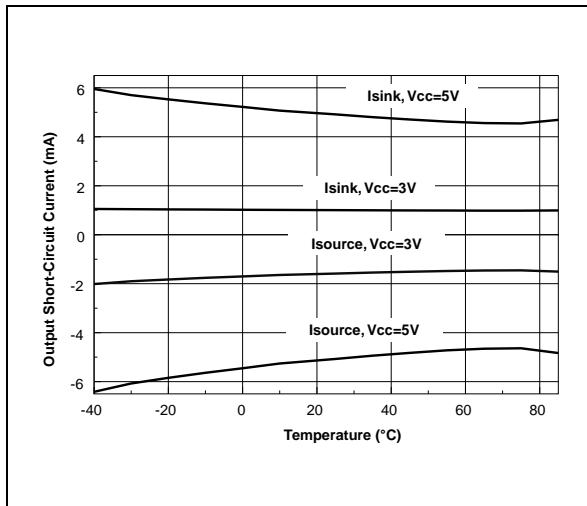


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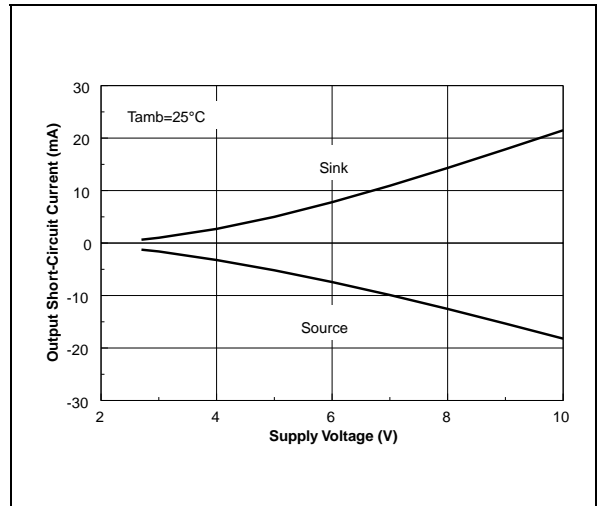


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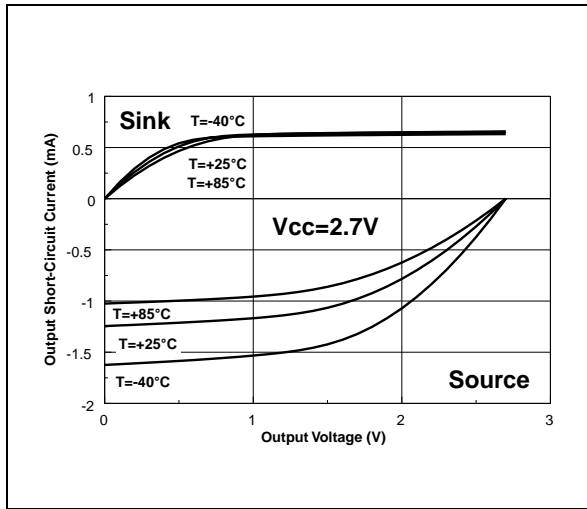


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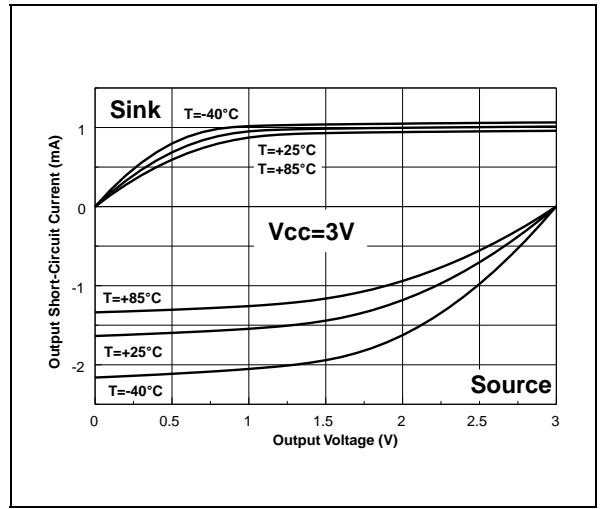


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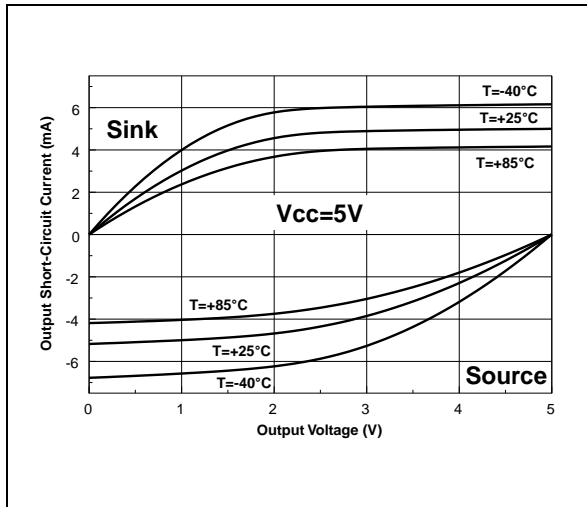


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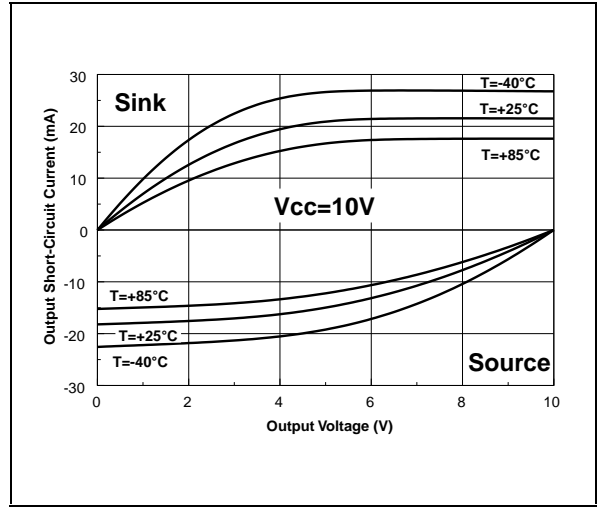


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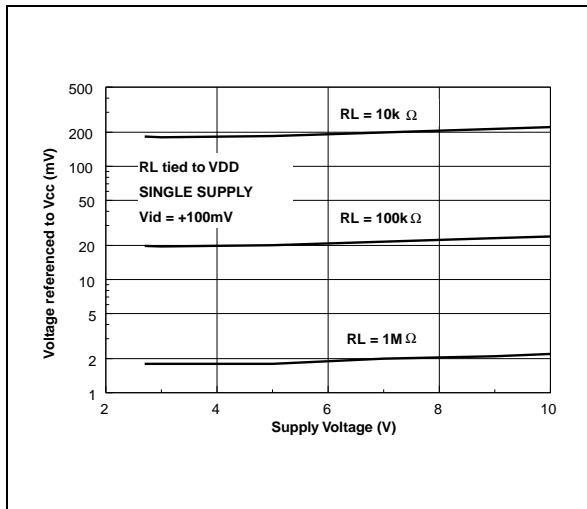


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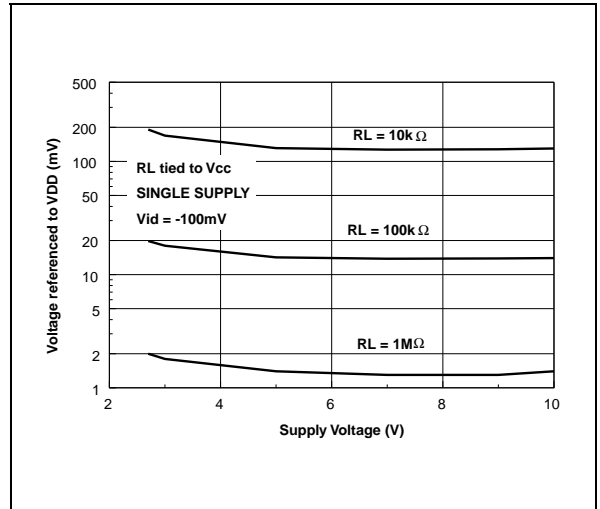


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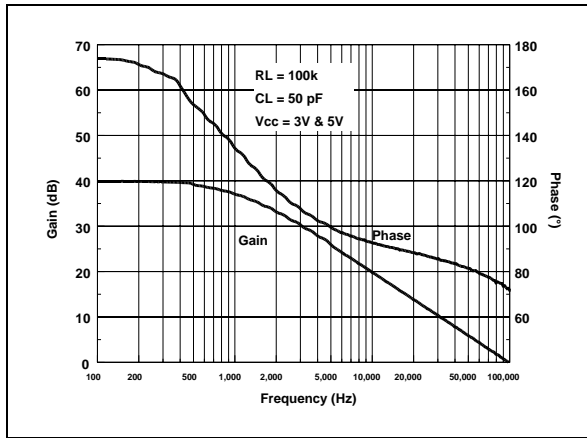


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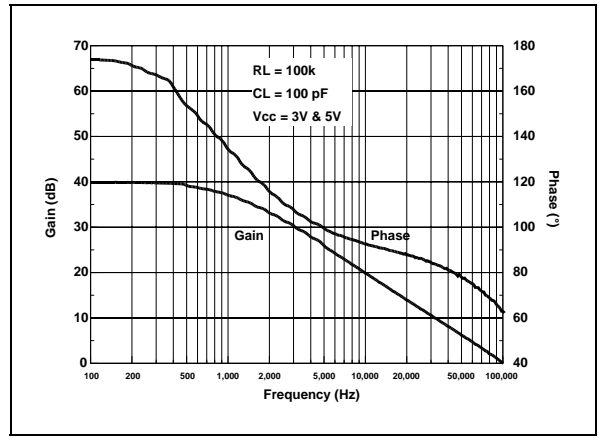


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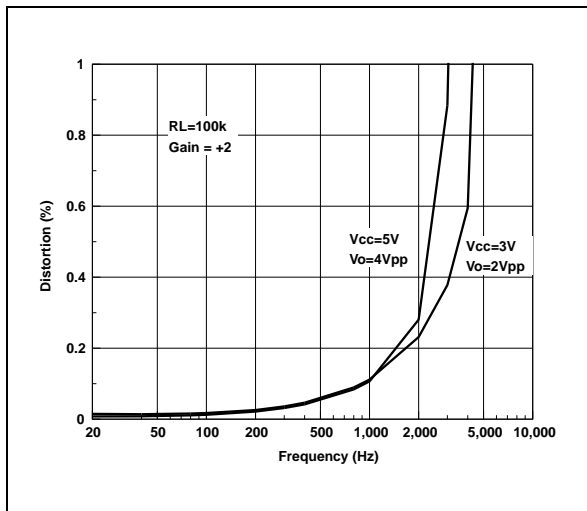


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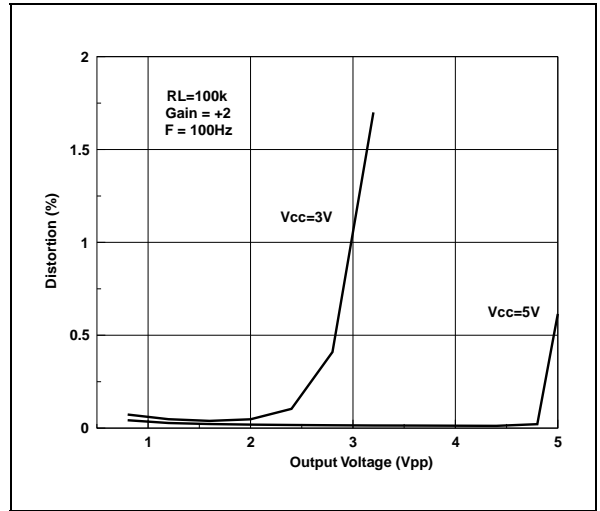


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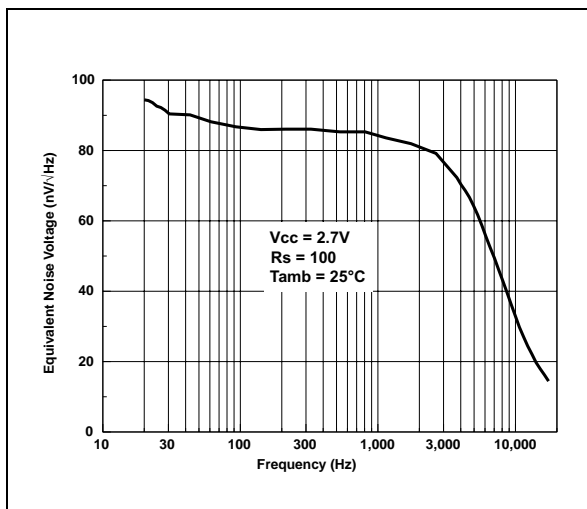


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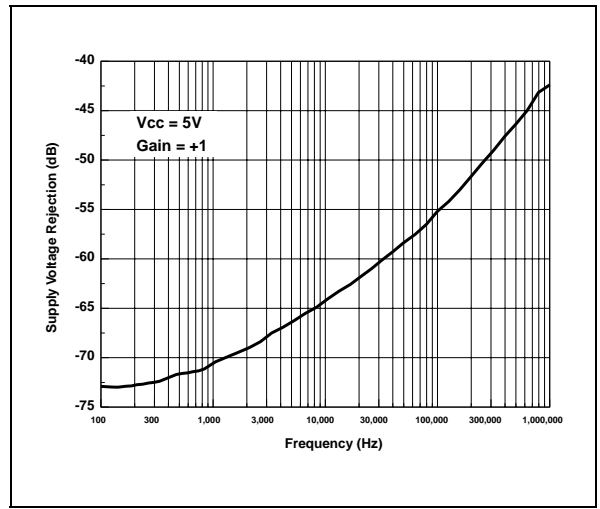


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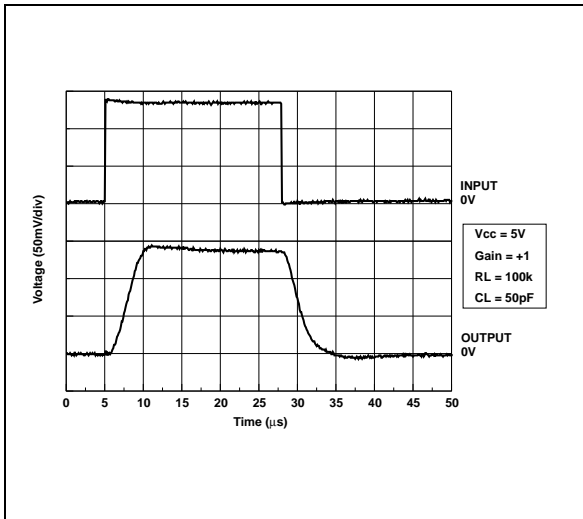
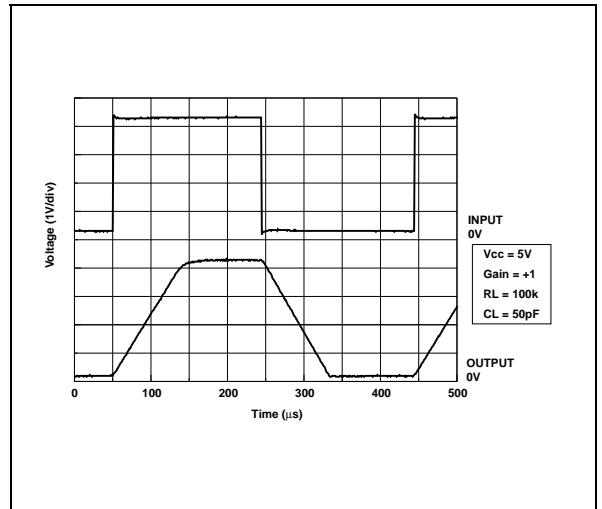


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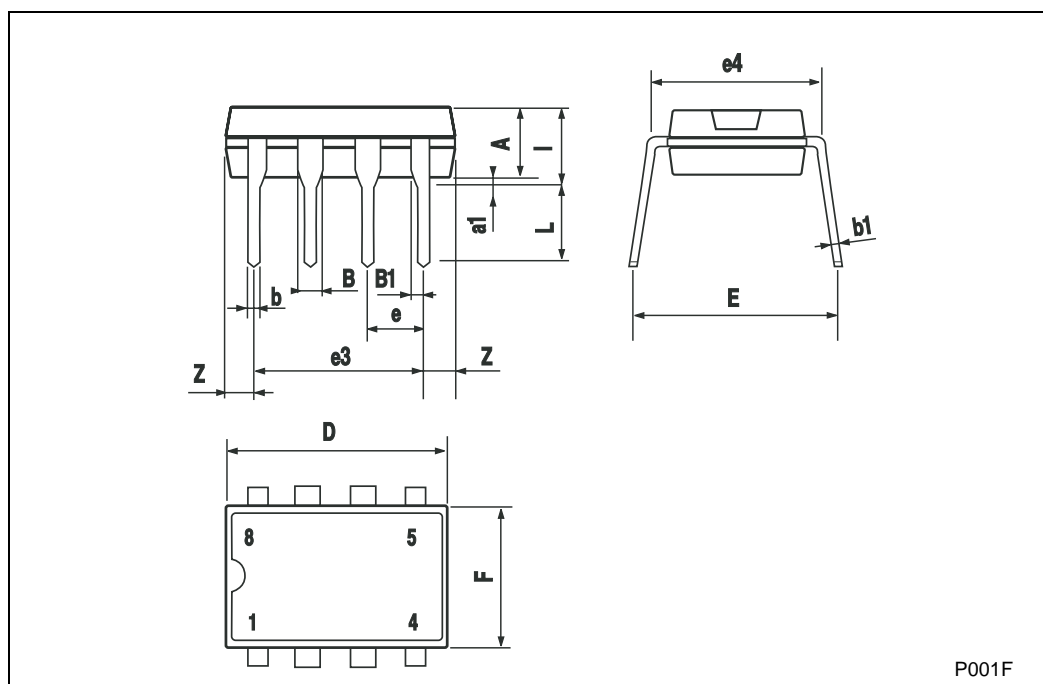


### 3 Package Mechanical Data

#### 3.1 DIP8 package

**Plastic DIP-8 MECHANICAL DATA**

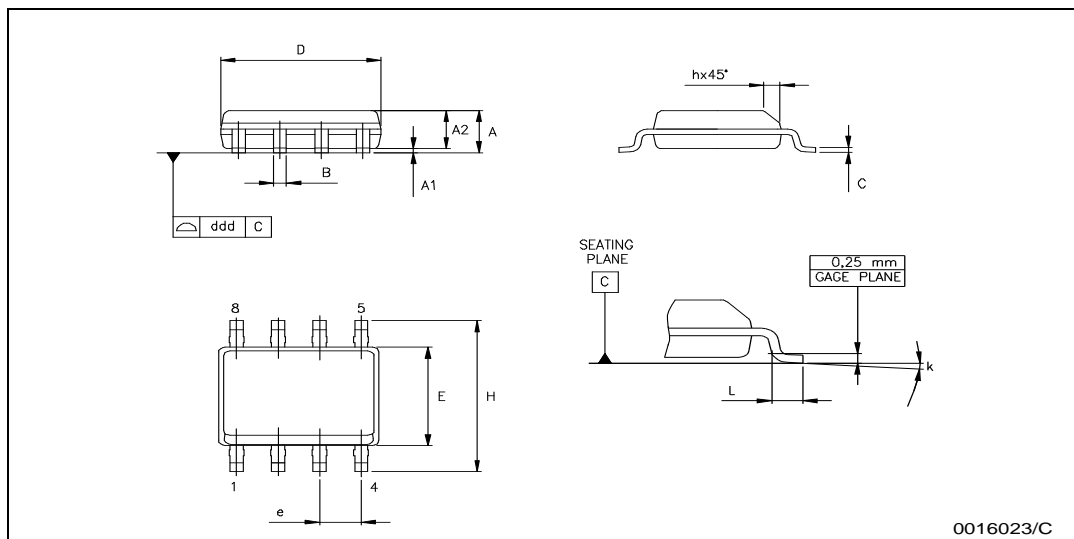
DIM.	mm.			inch		
	MIN.	TYP	MAX.	MIN.	TYP.	MAX.
A		3.3			0.130	
a1	0.7			0.028		
B	1.39		1.65	0.055		0.065
B1	0.91		1.04	0.036		0.041
b		0.5			0.020	
b1	0.38		0.5	0.015		0.020
D			9.8			0.386
E		8.8			0.346	
e		2.54			0.100	
e3		7.62			0.300	
e4		7.62			0.300	
F			7.1			0.280
I			4.8			0.189
L		3.3	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



3.2 SO8 package

**SO-8 MECHANICAL DATA**

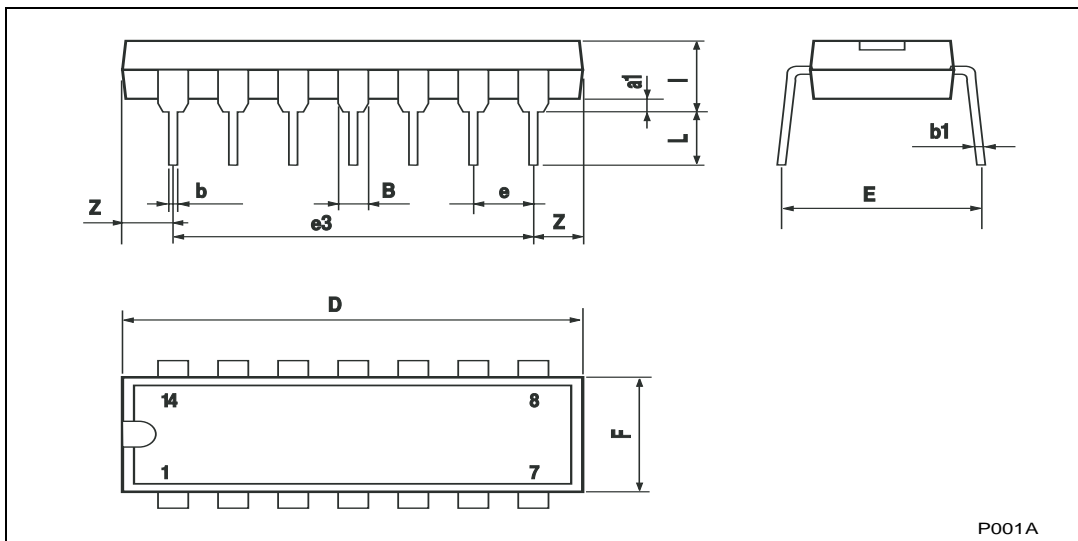
DIM.	mm.			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A	1.35		1.75	0.053		0.069
A1	0.10		0.25	0.04		0.010
A2	1.10		1.65	0.043		0.065
B	0.33		0.51	0.013		0.020
C	0.19		0.25	0.007		0.010
D	4.80		5.00	0.189		0.197
E	3.80		4.00	0.150		0.157
e		1.27			0.050	
H	5.80		6.20	0.228		0.244
h	0.25		0.50	0.010		0.020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



3.3 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

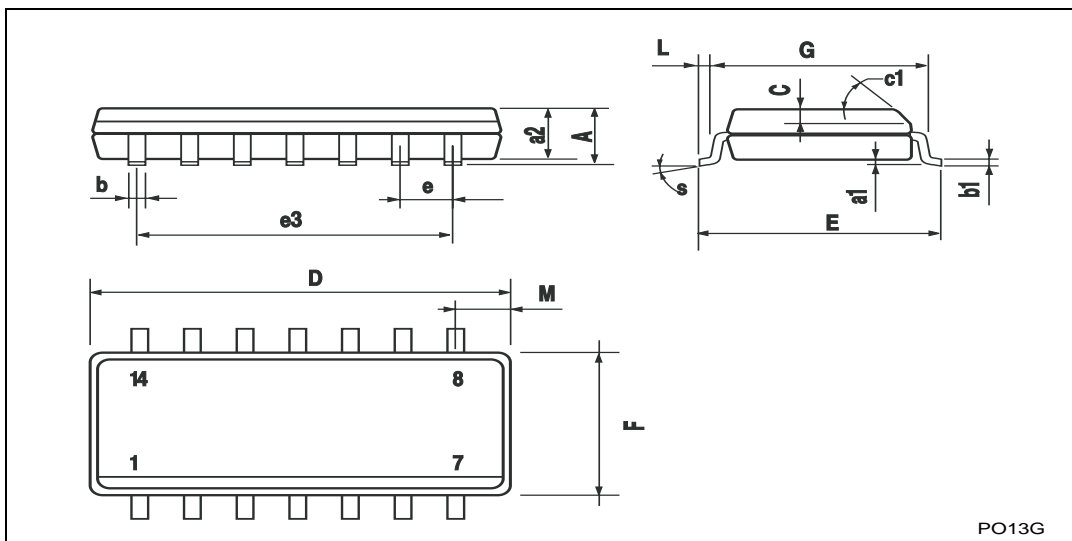


P001A

3.4 SO14 package

**SO-14 MECHANICAL DATA**

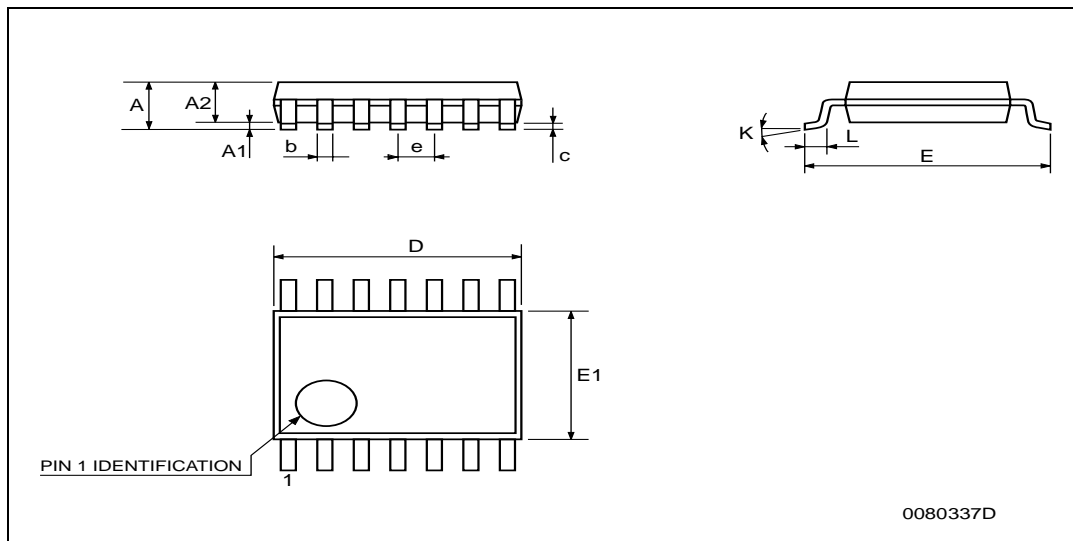
DIM.	mm.			inch		
	MIN.	TYP	MAX.	MIN.	TYP.	MAX.
A			1.75			0.068
a1	0.1		0.2	0.003		0.007
a2			1.65			0.064
b	0.35		0.46	0.013		0.018
b1	0.19		0.25	0.007		0.010
C		0.5			0.019	
c1	45° (typ.)					
D	8.55		8.75	0.336		0.344
E	5.8		6.2	0.228		0.244
e		1.27			0.050	
e3		7.62			0.300	
F	3.8		4.0	0.149		0.157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



3.5 TSSOP14 package

**TSSOP14 MECHANICAL DATA**

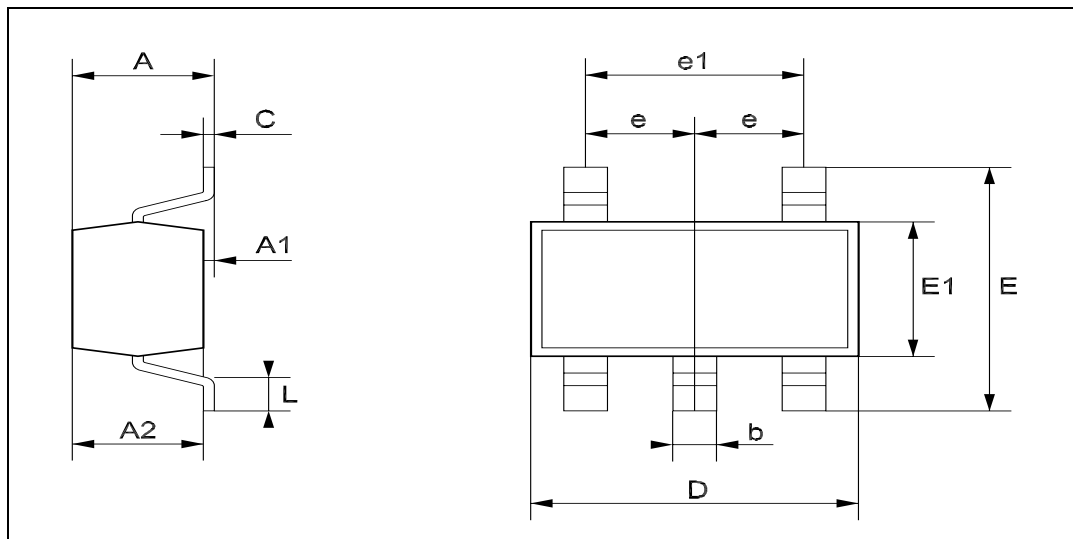
DIM.	mm.			inch		
	MIN.	TYP	MAX.	MIN.	TYP.	MAX.
A			1.2			0.047
A1	0.05		0.15	0.002	0.004	0.006
A2	0.8	1	1.05	0.031	0.039	0.041
b	0.19		0.30	0.007		0.012
c	0.09		0.20	0.004		0.0089
D	4.9	5	5.1	0.193	0.197	0.201
E	6.2	6.4	6.6	0.244	0.252	0.260
E1	4.3	4.4	4.48	0.169	0.173	0.176
e		0.65 BSC			0.0256 BSC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



## 3.6 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



## 4 Summary of Changes

Date	Revision	Description of Changes
01 Nov 2001	1	First Release
01 Dec 2004	2	Modifications on AMR table page 2 (explanation of Vid and Vi limits)

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