TS941-TS942-TS944

Output Rail-to-Rail Micropower Operational Amplifiers

- **Rail-to-rail output voltage swing**
- **Micropower consumption (1.2µA)**
- **Single supply operation (2.5V to 10V)**
- **CMOS inputs**
- **Ultra low input bias current (1pA)**
- **ESD protection (2kV)**
- **Latch-up immunity (class A)**
- **Available in SOT23-5 micropackage**

Description

The TS94x (single, dual & quad) series are operational amplifiers characterized for 2.5V to 10V operation over -40°C to +85°C temperature range.

They exhibit excellent consumption - 1.2µA, while featuring 10kHz gain bandwidth product, 1.5mA output capability and output rail-to-rail operation - 2.85V typ @ 3V with RL=10kΩ.

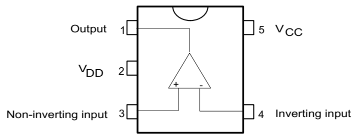
The TS94x op-amps are ideal for battery-powered systems, where very low supply current and output rail-to-rail are required. Their very low - 1pA typ input bias current and constant supply current over supply voltage enhance TS94x's performance near the end of the life battery charge.

Applications

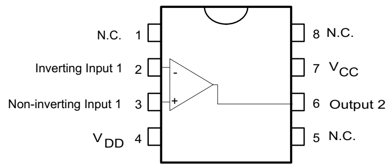
- **Battery-powered systems (alarm)**
- **Portable communication systems (pagers)**
- **Smoke/gas/fire detectors**
- **Instrumentation & sensoring**
- **PH meter**

Pin Connections (top view)

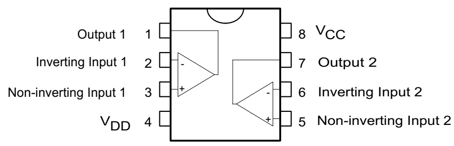
TS941ILT



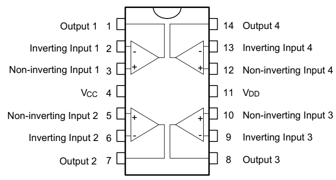
TS941ID-TS941IDT



TS942IN-TS942ID-TS942IDT-TS942IPT



TS944IN-TS944ID-TS944IDT-TS944IPT



Order Codes

Part Number	Temperature Range	Package	Packaging	Marking
TS941ID/IDT/AID/AIDT/BID/BIDT	-40°C, +85°C	SO	Tube or Tape & Reel	
TS941ILT/AILT/BILT		SOT23-5L	Tape & Reel	K201 K202 K203
TS942IN/AIN/BIN		DIP	Tube	
TS942ID/IDT/AID/AIDT/BID/BIDT		SO	Tube or Tape & Reel	
TS942IPT/AIPT/BIPT		TSSOP (Thin Shrink Outline Package)	Tape & Reel	
TS944IN/AIN/BIN		DIP	Tube	
TS944ID/IDT/AID/AIDT/BIDT/BIDT		SO	Tube or Tape & Reel	
TS944IPT/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 [1]	12	V
Vid	Differential Input Voltage [2]	±12	V
V_{in}	Input Voltage Range [3]	Vdd-0.3 to Vcc+0.3	V
T_{std}	Storage Temperature Range	-65 to +150	°C
T_j	Maximum Junction Temperature	150	°C
R_{thja}	Thermal Resistance Junction to Ambient [4] SOT23-5 DIP8 DIP14 SO8 SO14 TSSOP8 TSSOP14	250 85 66 125 103 120 100	°C/W
ESD	HBM: Human Body Model[5]	2	kV
	MM: Machine Model[6] (TS941, TS942)	200	V
	CDM: Charged Device Model TS941	1.5	kV
	TS942	1	kV
	Latch-up Immunity	200	mA
	Lead Temperature (soldering, 10sec)	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_{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
VCC	Supply Voltage	2.5 to 10	V
Vicm	Common Mode Input Voltage Range	V_{DD} -0.2 to V_{CC} -1.3	V
T_{oper}	Operating Free Air Temperature Range	-40 to + 85	°C

2 Electrical Characteristics

Table 3: V_{CC} = +2.5V, V_{DD} = 0V, R_L connected to $V_{CC/2}$, T_{amb} = 25°C (unless otherwise specified)

Symbol	Parameter		Min.	Typ.	Max.	Unit
V_{io}	Input Offset Voltage	TS941/2/4 TS941/2/4A TS941/2/4B			10 5 2	mV
ΔV_{io}	Input Offset Voltage Drift			7		µV/°C
I_{io}	Input Offset Current [1]			1	100	pA
I_{ib}	Input Bias Current [1)]			1	150	pA
CMR	Common Mode Rejection Ratio		60	85		dB
SVR	Supply Voltage Rejection Ratio		50	78		dB
A_{vd}	Large Signal Voltage Gain V_O = 2Vpp	R_L = 1MΩ		100		dB
V_{OH}	High Level Output Voltage V_{ID} = 100mV	R_L = 1MΩ R_L = 10kΩ	2.45 2.3	2.49 2.4		V
V_{OL}	Low Level Output Voltage V_{ID} = -100mV	R_L = 1MΩ R_L = 10kΩ		1 100	5 200	mV
I_o	Output Source Current V_{ID} = 100mV, $V_O = V_{DD}$ Output Sink Current V_{ID} = -100mV, $V_O = V_{CC}$		350 280	650 500		µA
I_{CC}	Supply Current (per amplifier) A_{VCL} = 1, no load			1.2	1.8	µA
GBP	Gain Bandwidth Product	R_L = 1MΩ, C_L = 50pF		10		kHz
SR	Slew Rate	R_L = 1MΩ, C_L = 50pF	3	4.5		V/ms
φm	Phase Margin	C_L = 50pF		65		Degrees

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

Table 4: V_{CC} = +3V, V_{DD} = 0V, R_L connected to $V_{CC/2}$,T_{amb} = 25°C (unless otherwise specified) [2)]

Symbol	Parameter		Min.	Typ.	Max.	Unit
V_{io}	Input Offset Voltage	TS941/2/4 TS941/2/4A TS941/2/4B			10 5 2	mV
ΔV_{io}	Input Offset Voltage Drift			7		µV/°C
I_{io}	Input Offset Current [1]			1	100	pA
I_{ib}	Input Bias Current [1)]			1	150	pA
CMR	Common Mode Rejection Ratio		60	85		dB
SVR	Supply Voltage Rejection Ratio		50	85		dB
A_{vd}	Large Signal Voltage Gain	V_O = 2VppR_L = 1MΩ		100		dB
V_{OH}	High Level Output Voltage V_{ID} = 100mV	R_L = 1MΩ R_L = 10kΩ	2.9 2.8	2.99 2.85		V
V_{OL}	Low Level Output Voltage V_{ID} = -100mV	R_L = 1MΩ R_L = 10kΩ		1 100	5 200	mV
I_o	Output Source Current Output Sink Current	V_{ID} = 100mV, V_O = V_{DD} V_{ID} = -100mV, V_O = V_{CC}	680 650	1500 1300		µA
I_{CC}	Supply Current (per amplifier)	A_{VCL} = 1, no load		1.2	1.8	µA
GBP	Gain Bandwidth Product	R_L = 1MΩ, C_L = 50pF		10		kHz
SR	Slew Rate	R_L = 1MΩ, C_L = 50pF	3	4.5		V/ms
φm	Phase Margin	C_L = 50pF		65		Degrees

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

2. All electrical values are guaranteed with correlation measurements at 2.5V and 5V

Table 5: V_{CC} = +5V, V_{DD} = 0V, R_L connected to $V_{CC/2}$, T_{amb} = 25°C (unless otherwise specified)

Symbol	Parameter		Min.	Typ.	Max.	Unit
V_{io}	Input Offset Voltage	TS941/2/4 TS941/2/4A TS941/2/4B			10 5 2	mV
ΔV_{io}	Input Offset Voltage Drift			7		µV/°C
I_{io}	Input Offset Current [1]			1	100	pA
I_{ib}	Input Bias Current [1)]			1	150	pA
CMR	Common Mode Rejection Ratio		60	85		dB
SVR	Supply Voltage Rejection Ratio		50	85		dB
A_{vd}	Large Signal Voltage Gain V_O = 2Vpp	R_L = 1MΩ		100		dB
V_{OH}	High Level Output Voltage V_{ID} = 100mV	R_L = 1MΩ R_L = 10kΩ	4.9 4.8	4.99 4.85		V
V_{OL}	Low Level Output Voltage V_{ID} = -100mV	R_L = 1MΩ R_L = 10kΩ		1 100	5 150	mV
I_o	Output Source Current Output Sink Current	V_{ID} = 100mV, V_O = V_{DD} V_{ID} = -100mV, V_O = V_{CC}	3 3.7	4.5 5		mA
I_{CC}	Supply Current (per amplifier)	A_{VCL} = 1, no load		1.2	1.85	µA
GBP	Gain Bandwidth Product	R_L = 1MΩ, C_L = 50pF		10		kHz
SR	Slew Rate	R_L = 1MΩ, C_L = 50pF	3	4.5		V/ms
φm	Phase Margin	C_L = 50pF		65		Degrees

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

Figure 1:

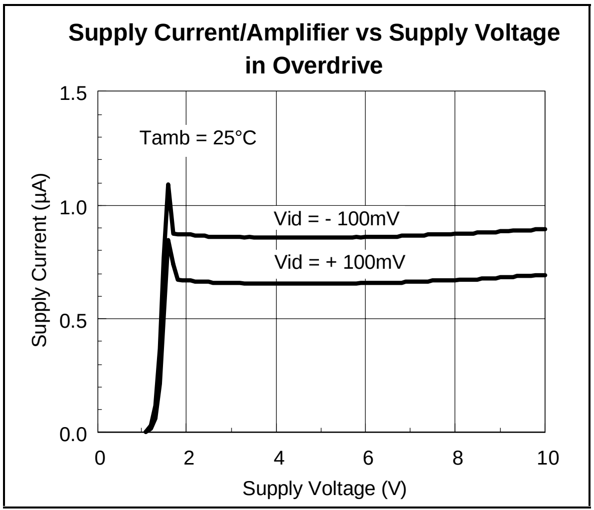


Figure 2:

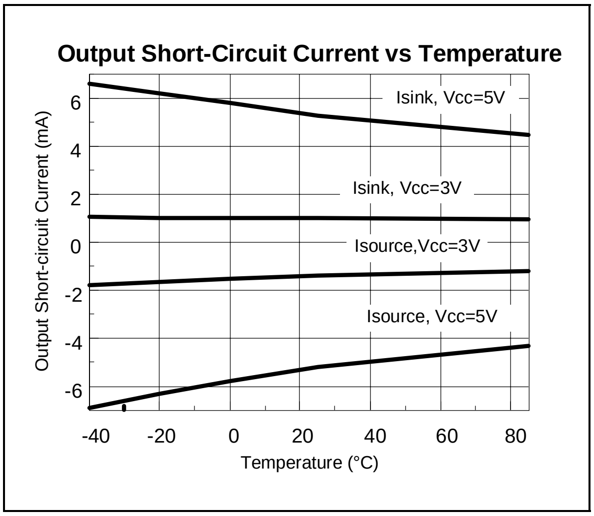
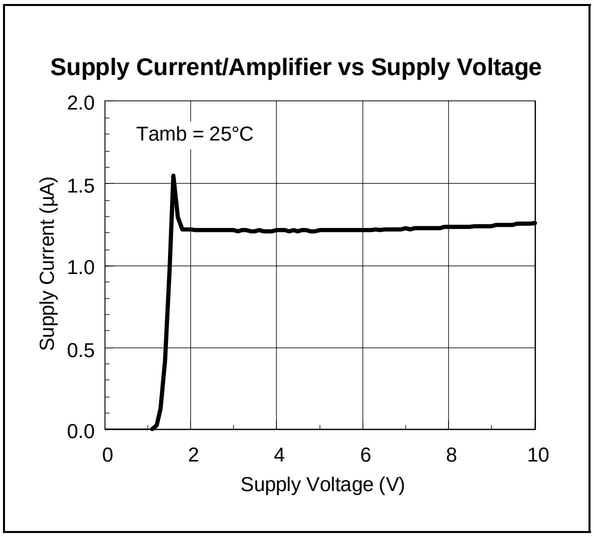


Figure 3:



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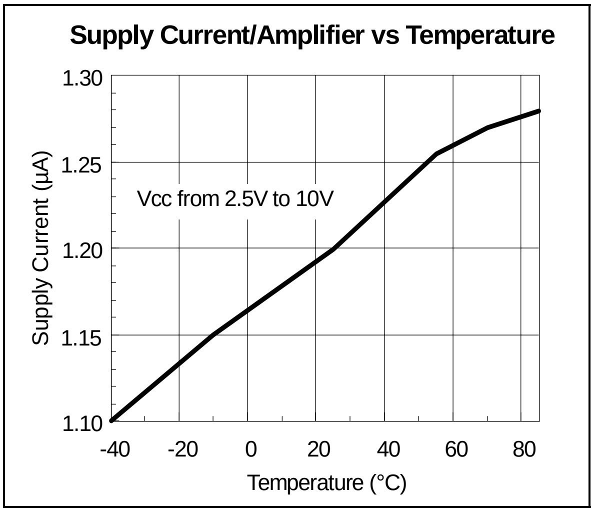

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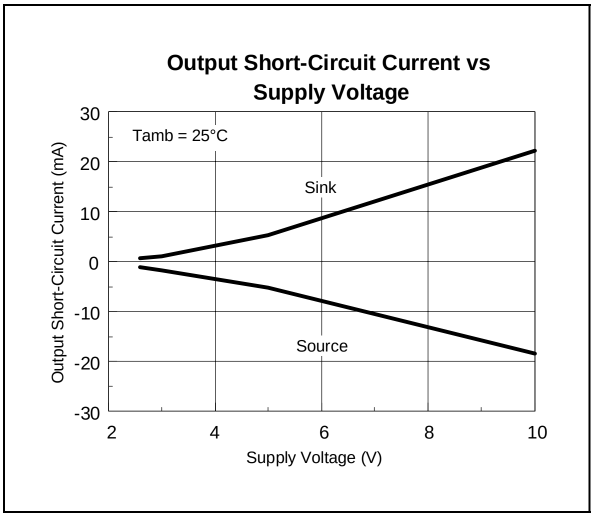

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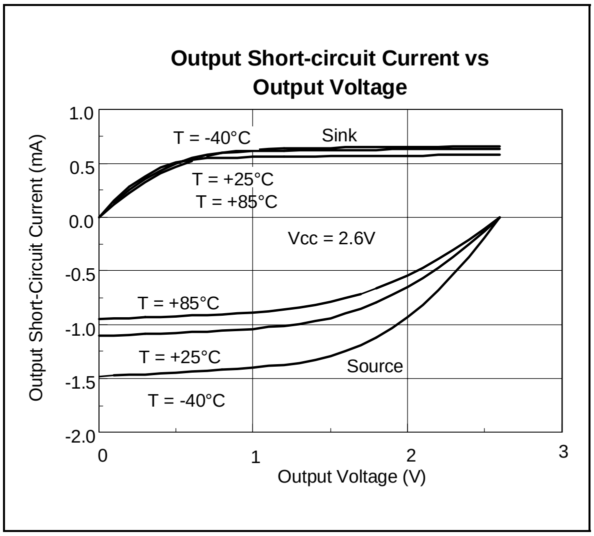

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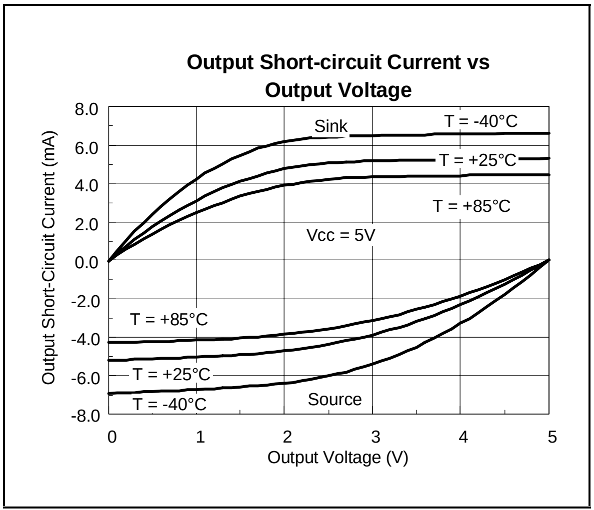

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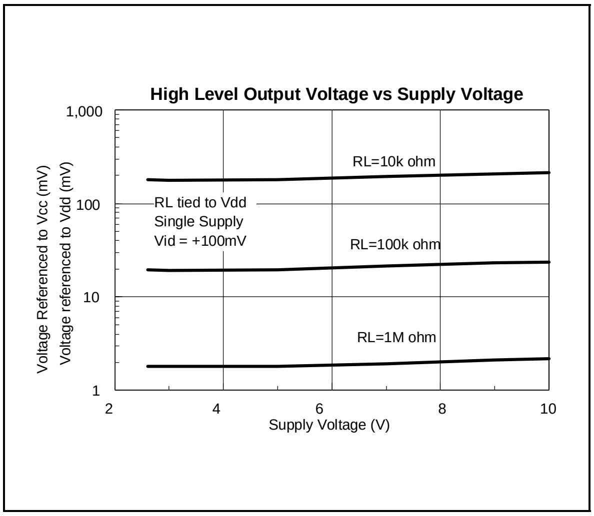

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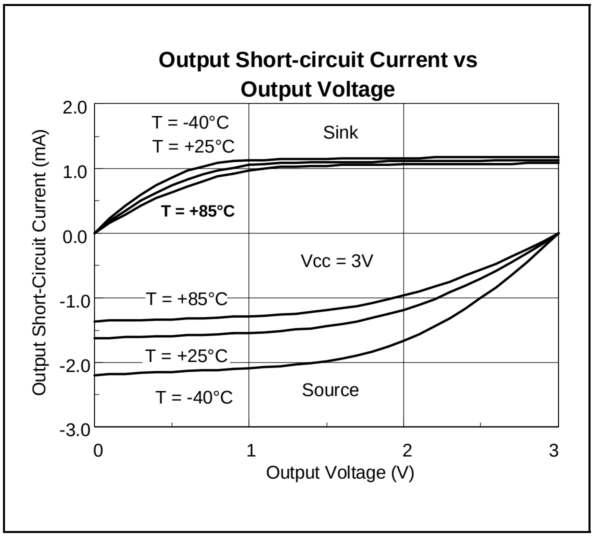

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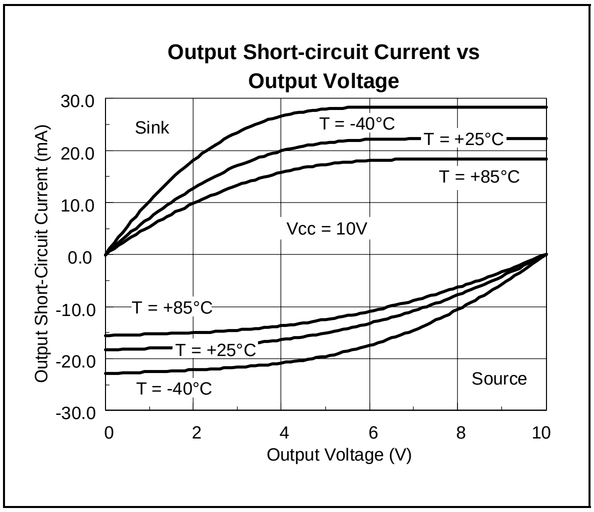

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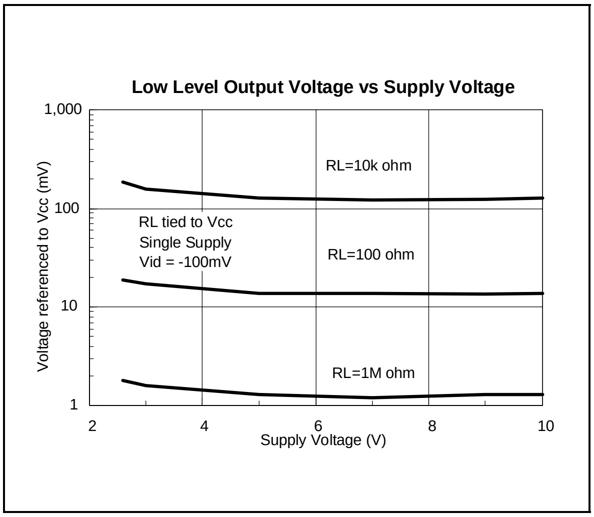

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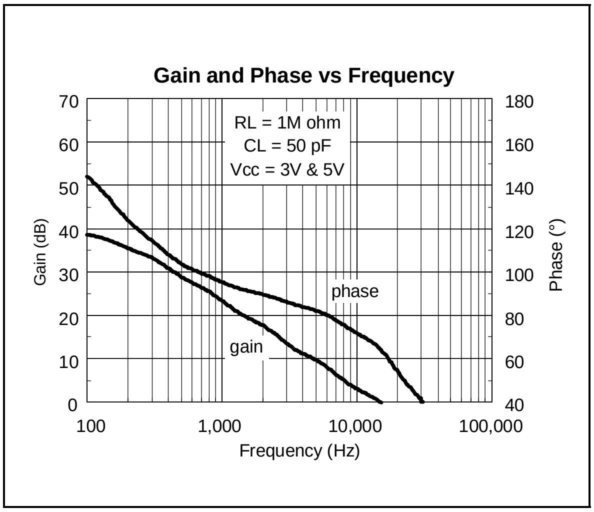

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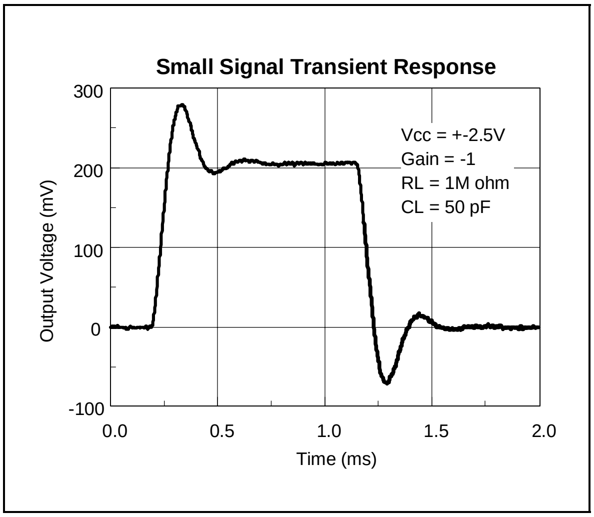

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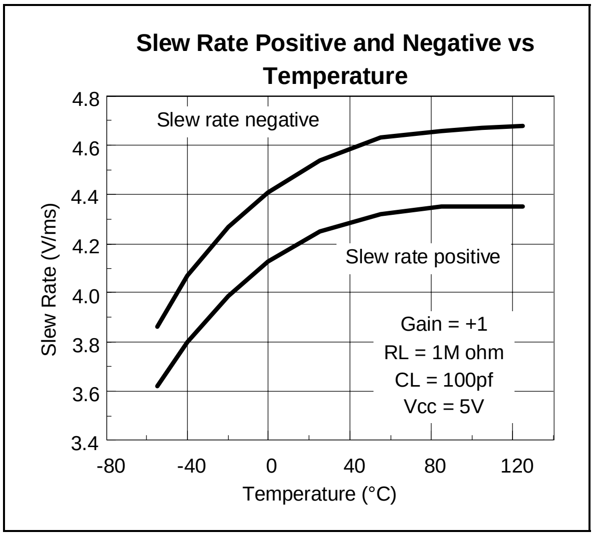

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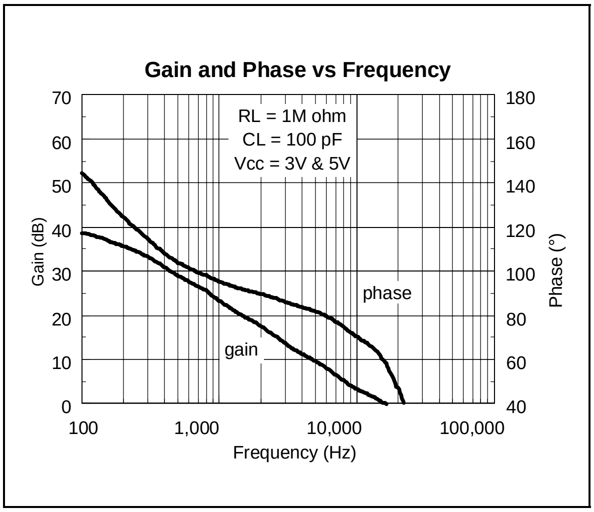

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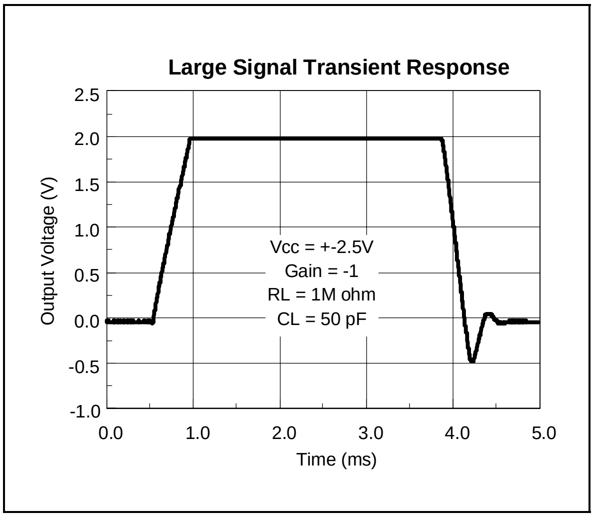
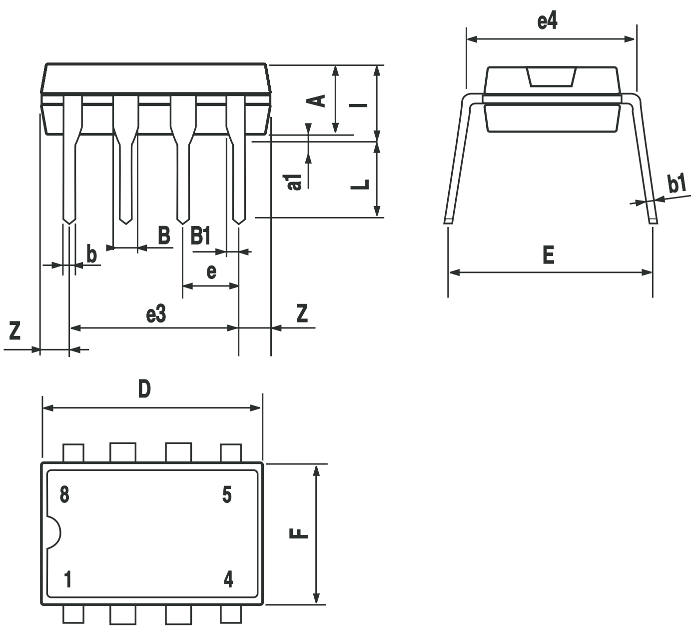


3 Package Mechanical Data

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

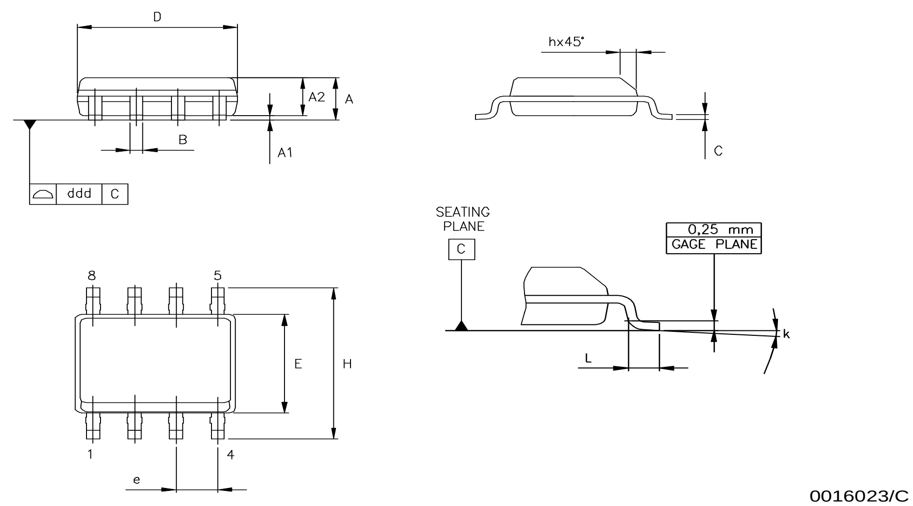


P001F

3.2 SO8 package

SO-8 MECHANICAL DATA

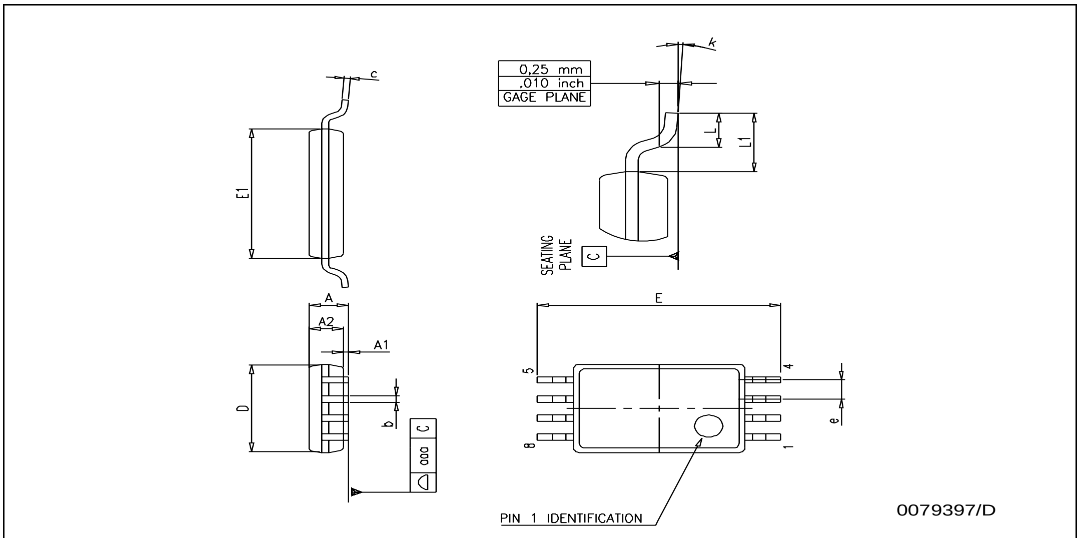
DIM.	mm.			inch		
	MIN.	TYP	MAX.	MIN.	TYP.	MAX.
A	1.35		1.75	0.053		0.069
A1	0.10		0.25	0.04		0.010
A2	1.10		1.65	0.043		0.065
B	0.33		0.51	0.013		0.020
C	0.19		0.25	0.007		0.010
D	4.80		5.00	0.189		0.197
E	3.80		4.00	0.150		0.157
e		1.27			0.050	
H	5.80		6.20	0.228		0.244
h	0.25		0.50	0.010		0.020
L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



3.3 TSSOP8 package

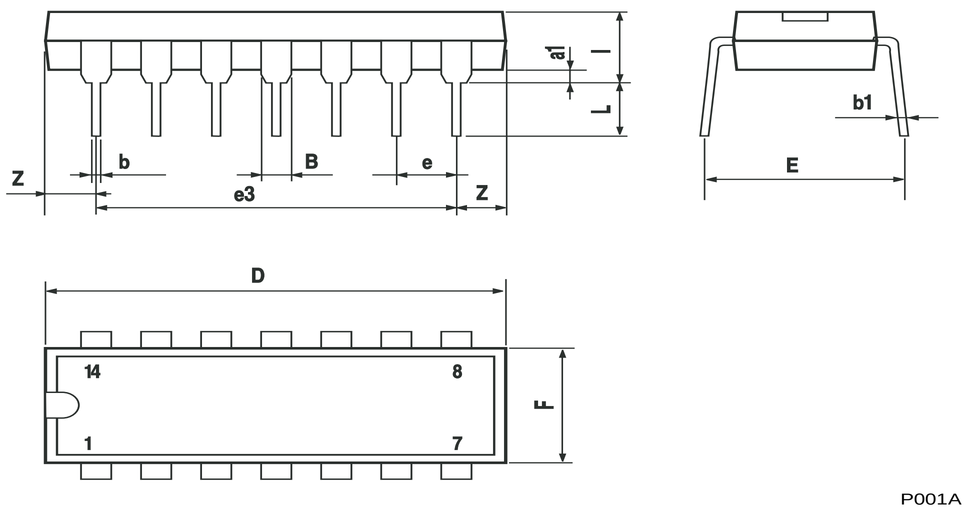
TSSOP8 MECHANICAL DATA

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

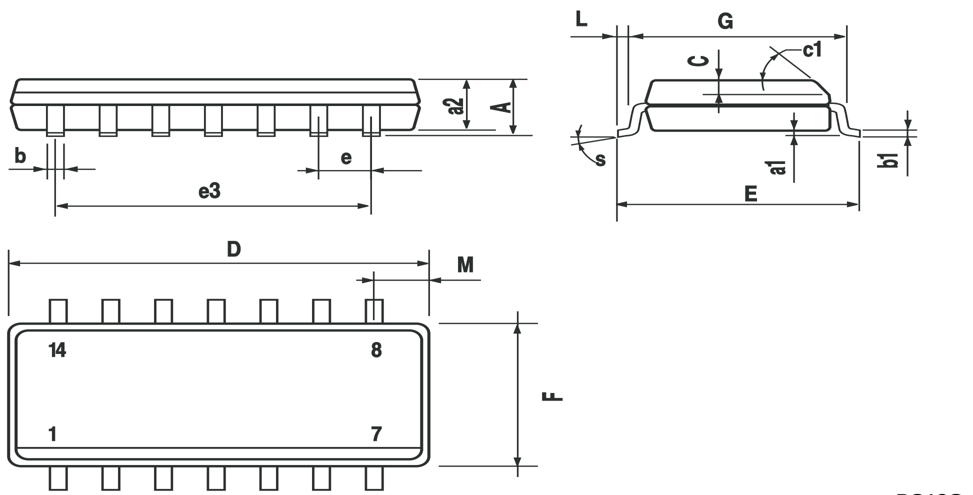
Plastic DIP-14 MECHANICAL DATA						
DIM.	mm.			inch		
	MIN.	TYP	MAX.	MIN.	TYP.	MAX.
a1	0.51			0.020		
B	1.39		1.65	0.055		0.065
b		0.5			0.020	
b1		0.25			0.010	
D			20			0.787
E		8.5			0.335	
e		2.54			0.100	
e3		15.24			0.600	
F			7.1			0.280
I			5.1			0.201
L		3.3			0.130	
Z	1.27		2.54	0.050		0.100



3.5 SO14 package

SO-14 MECHANICAL DATA

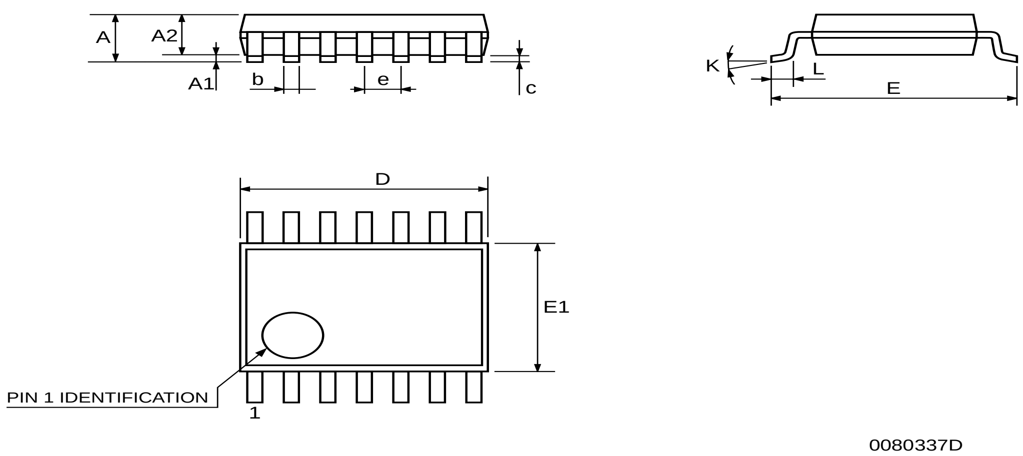
DIM.	mm.			inch		
	MIN.	TYP	MAX.	MIN.	TYP.	MAX.
A			1.75			0.068
a1	0.1		0.2	0.003		0.007
a2			1.65			0.064
b	0.35		0.46	0.013		0.018
b1	0.19		0.25	0.007		0.010
C		0.5			0.019	
c1	45° (typ.)					
D	8.55		8.75	0.336		0.344
E	5.8		6.2	0.228		0.244
e		1.27			0.050	
e3		7.62			0.300	
F	3.8		4.0	0.149		0.157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

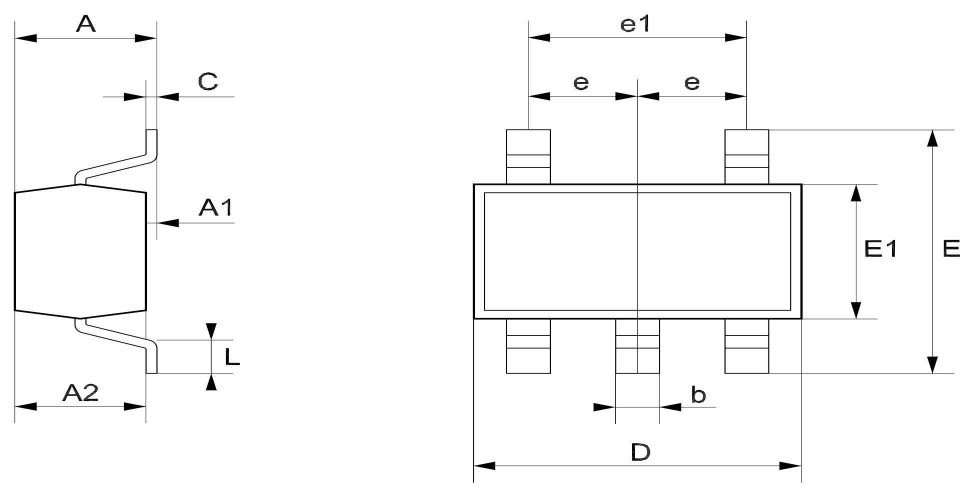
TSSOP14 MECHANICAL DATA

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



4 Summary of Changes OU

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

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