



**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) is Operational Amplifier characterized for 2.5V to 10V operation over -40°C to +85°C temperature range.

It is exhibiting an 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-Amp is ideal for battery-powered systems, where very low supply current and output Rail to Rail are required. Its 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.

APPLICATION

- Battery-powered systems (Alarm)
- Portable communication systems (Paggers)
- Smoke/gas/fire detectors
- Instrumentation & sensing
- PH Meter

ORDER CODE

Part Number	Temperature Range	Package				SOT23 Marking
		N	D	P	L	
TS941I TS941AI TS941BI	-40, +85°C		•		•	K201 K202 K203
TS942I TS942AI TS942BI	-40, +85°C	•	•	•		
TS944I TS944AI TS944BI	-40, +85°C	•	•	•		

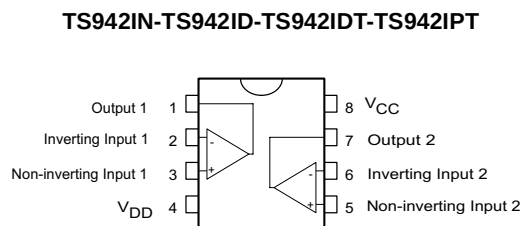
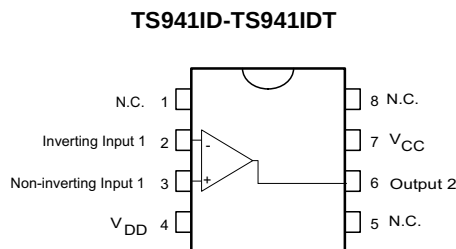
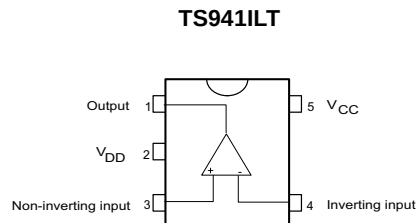
N = Dual in Line Package (DIP)

D = Small Outline Package (SO) - also available in Tape & Reel (DT)

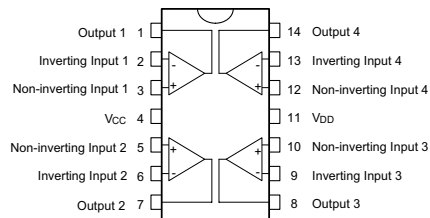
P = Thin Shrink Small Outline Package (TSSOP) - only available in Tape & Reel (PT)

L = Tiny Package (SOT23-5) - only available in Tape & Reel (LT)

PIN CONNECTIONS (top view)



TS944IN-TS944ID-TS944IDT-TS944IPT



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CC}	Supply voltage ¹⁾	12	V
V_{id}	Differential Input Voltage ²⁾	± 12	V
V_{in}	Input Voltage Range ³⁾	-0.3 to 12.3	V
T_{oper}	Operating Free Air Temperature Range	-40 to + 85	°C
T_{std}	Storage Temperature Range	-65 to +150	°C
T_j	Maximum Junction Temperature	150	°C
R_{thjc}	Thermal Resistance Junction to Case ⁴⁾ SOT23-5 DIP8 DIP14 SO8 SO14 TSSOP8 TSSOP14	81 42 32 28 22 26 21	°C/W
R_{thja}	Thermal Resistance Junction to Ambient - SOT23-5	256	°C/W
ESD	Human Body Model	2	kV
	Latch-up Immunity	Class A	
	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.

OPERATING CONDITIONS

Symbol	Parameter	Value	Unit
V_{CC}	Supply Voltage	2.5 to 10	V
V_{icm}	Common Mode Input Voltage Range	$V_{CC}^- - 0.2$ to $V_{CC}^+ - 1.3$	V

ELECTRICAL CHARACTERISTICS

$V_{CC} = +2.5V$, $V_{DD} = 0V$, R_L connected to $V_{CC/2}$,
 $T_{amb} = 25^{\circ}C$ (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		$\mu V/^{\circ}C$
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 $V_O = 2V_{pp}$ $R_L = 1M\Omega$		100		dB
V_{OH}	High Level Output Voltage $V_{ID} = 100mV$ $R_L = 1M\Omega$ $R_L = 10k\Omega$	2.45 2.3	2.49 2.4		V
V_{OL}	Low Level Output Voltage $V_{ID} = -100mV$ $R_L = 1M\Omega$ $R_L = 10k\Omega$		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 $R_L = 1M\Omega$, $C_L = 50pF$		10		kHz
SR	Slew Rate $R_L = 1M\Omega$, $C_L = 50pF$	3	4.5		V/ms
ϕ_m	Phase Margin $C_L = 50pF$		65		Degrees

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

ELECTRICAL CHARACTERISTICS

$V_{CC} = +3V$, $V_{DD} = 0V$, R_L connected to $V_{CC/2}$,
 $T_{amb} = 25^{\circ}C$ (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		$\mu V/^{\circ}C$
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 $V_O = 2V_{pp}$ $R_L = 1M\Omega$		100		dB
V_{OH}	High Level Output Voltage $V_{ID} = 100mV$ $R_L = 1M\Omega$ $R_L = 10k\Omega$	2.9 2.8	2.99 2.85		V
V_{OL}	Low Level Output Voltage $V_{ID} = -100mV$ $R_L = 1M\Omega$ $R_L = 10k\Omega$		1 100	5 200	mV
I_o	Output Source Current $V_{ID} = 100mV$, $V_O = V_{DD}$ Output Sink Current $V_{ID} = -100mV$, $V_O = V_{CC}$	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 $R_L = 1M\Omega$, $C_L = 50pF$		10		kHz
SR	Slew Rate $R_L = 1M\Omega$, $C_L = 50pF$	3	4.5		V/ms
ϕ_m	Phase Margin $C_L = 50pF$		65		Degrees

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

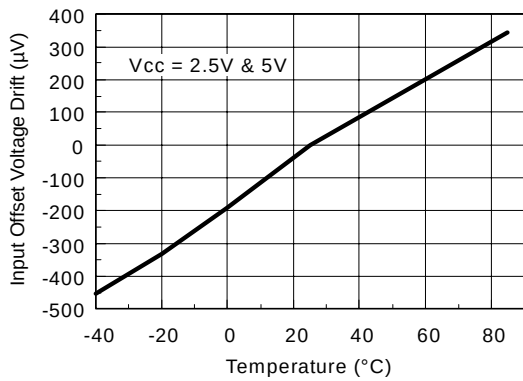
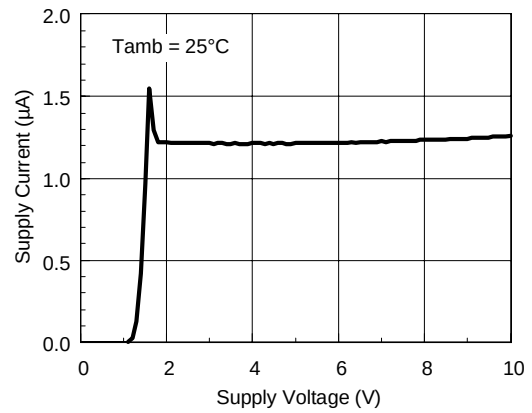
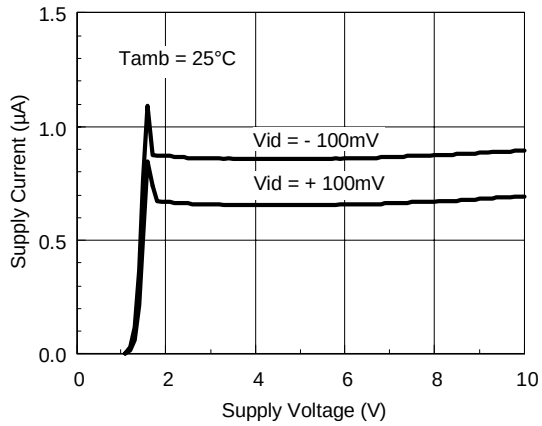
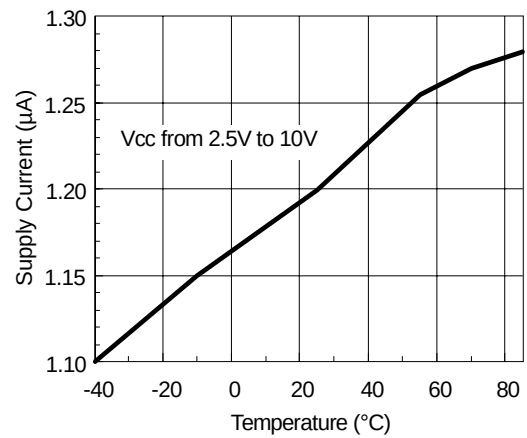
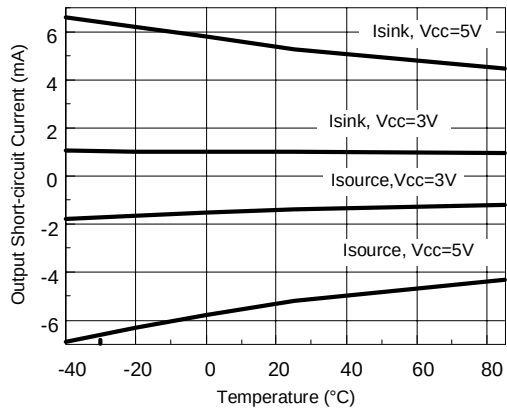
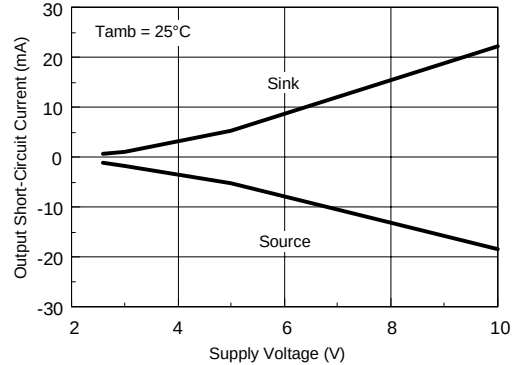
2. All electrical values are guaranteed with correlation measurements at 2.5V and 5V

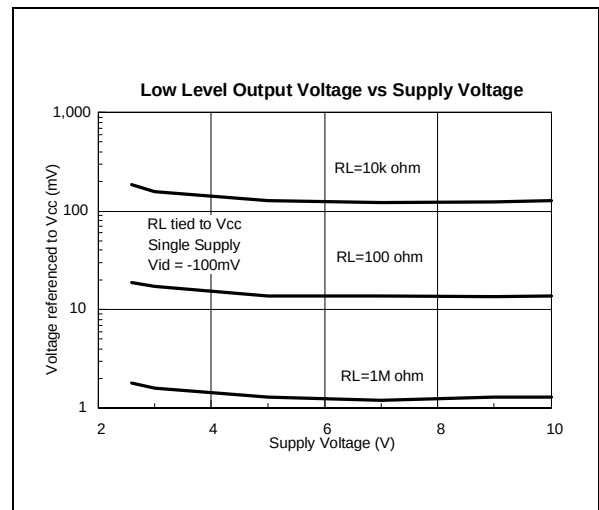
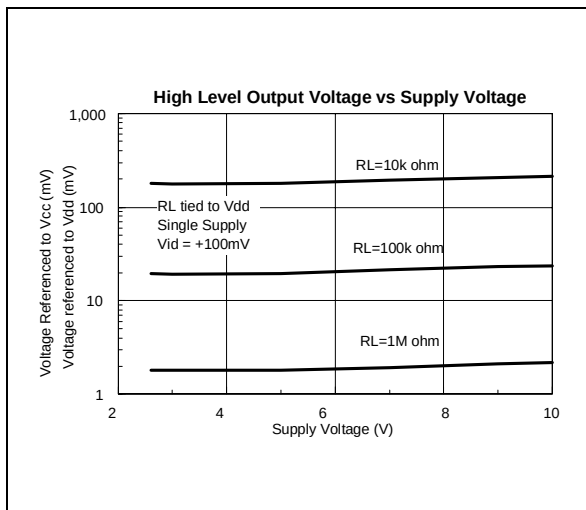
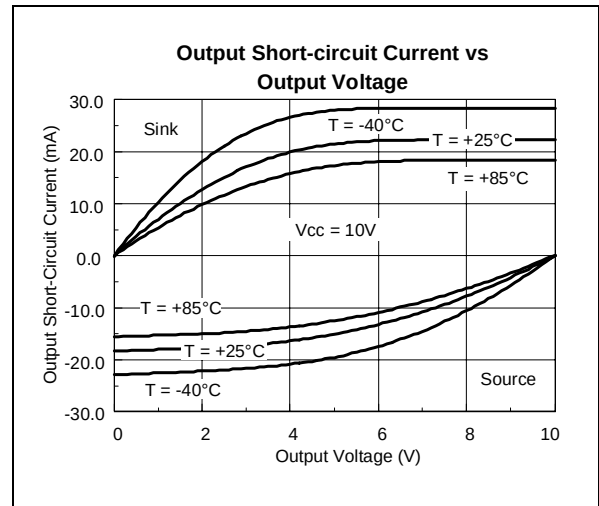
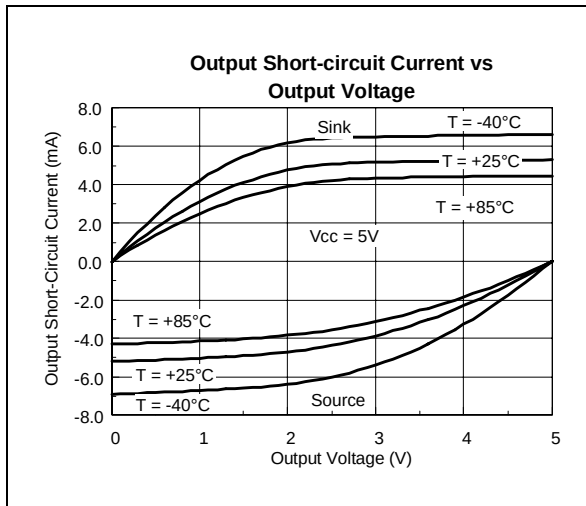
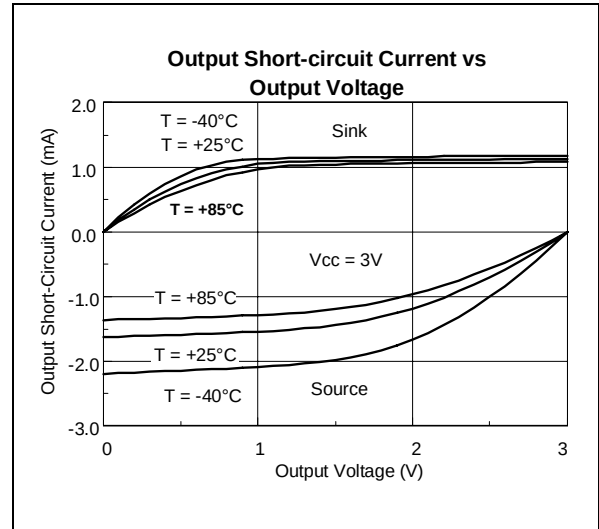
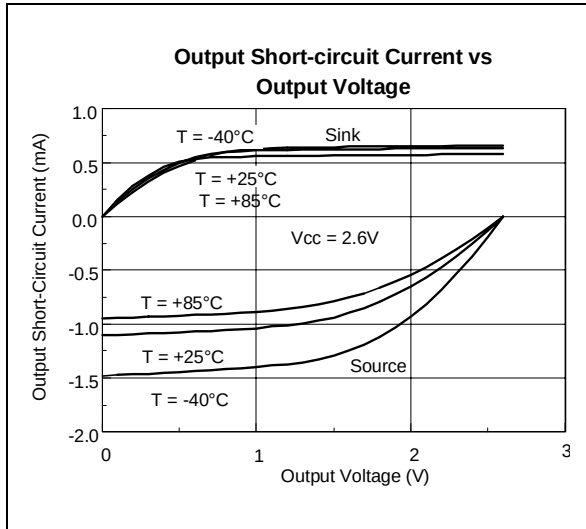
ELECTRICAL CHARACTERISTICS
 $V_{CC} = +5V$, $V_{DD} = 0V$, R_L connected to $V_{CC/2}$,

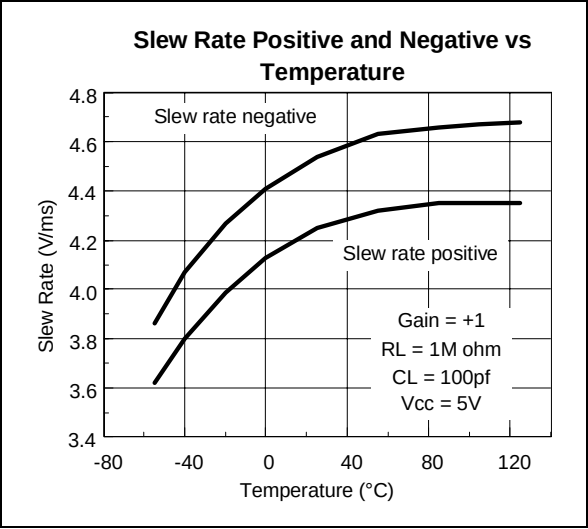
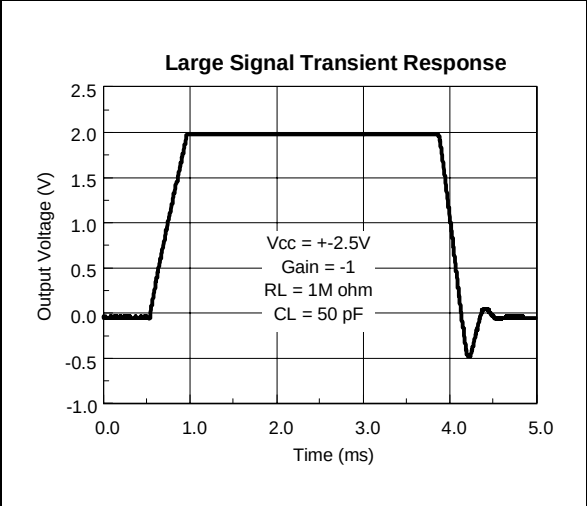
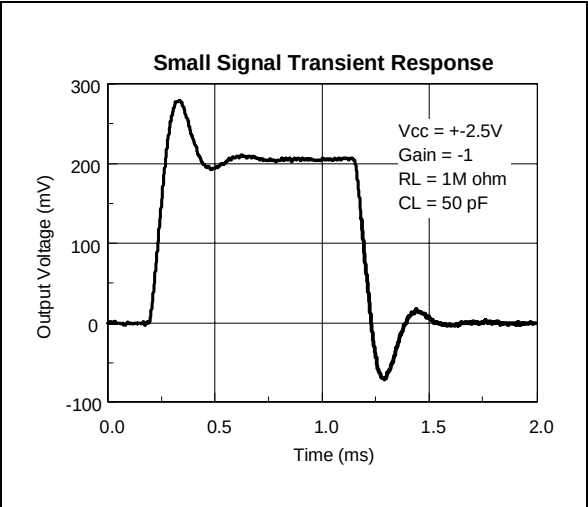
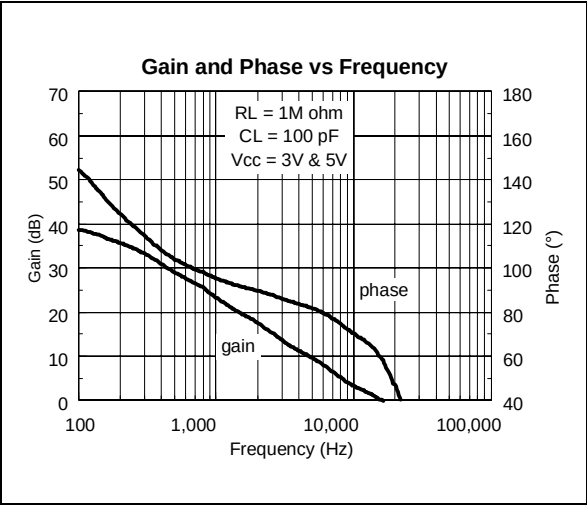
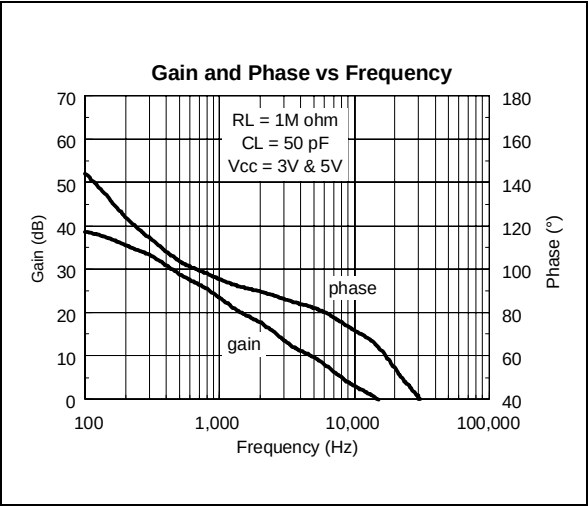
 $T_{amb} = 25^{\circ}C$ (unless otherwise specified)

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		$\mu V/^{\circ}C$
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 $V_O = 2V_{pp}$ $R_L = 1M\Omega$		100		dB
V_{OH}	High Level Output Voltage $V_{ID} = 100mV$ $R_L = 1M\Omega$ $R_L = 10k\Omega$	4.9 4.8	4.99 4.85		V
V_{OL}	Low Level Output Voltage $V_{ID} = -100mV$ $R_L = 1M\Omega$ $R_L = 10k\Omega$		1 100	5 150	mV
I_o	Output Source Current $V_{ID} = 100mV$, $V_O = V_{DD}$ Output Sink Current $V_{ID} = -100mV$, $V_O = V_{CC}$	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 $R_L = 1M\Omega$, $C_L = 50pF$		10		kHz
SR	Slew Rate $R_L = 1M\Omega$, $C_L = 50pF$	3	4.5		V/ms
ϕ_m	Phase Margin $C_L = 50pF$		65		Degrees

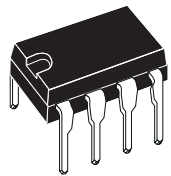
1. Maximum values including unavoidable inaccuracies of the industrial test.

Input Offset Voltage Drift vs Temperature**Supply Current/Amplifier vs Supply Voltage****Supply Current/Amplifier vs Supply Voltage in Overdrive****Supply Current/Amplifier vs Temperature****Output Short-Circuit Current vs Temperature****Output Short-Circuit Current vs Supply Voltage**

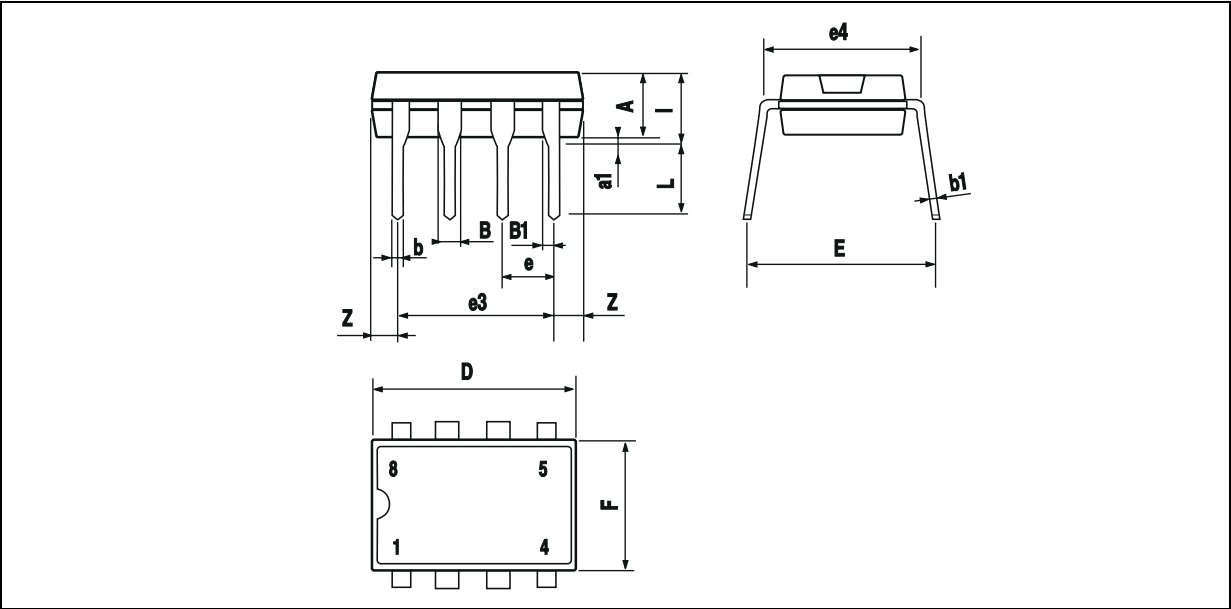




TS942IN

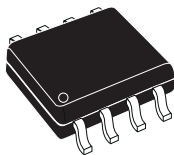


PACKAGE MECHANICAL DATA
8 PINS - PLASTIC PACKAGE

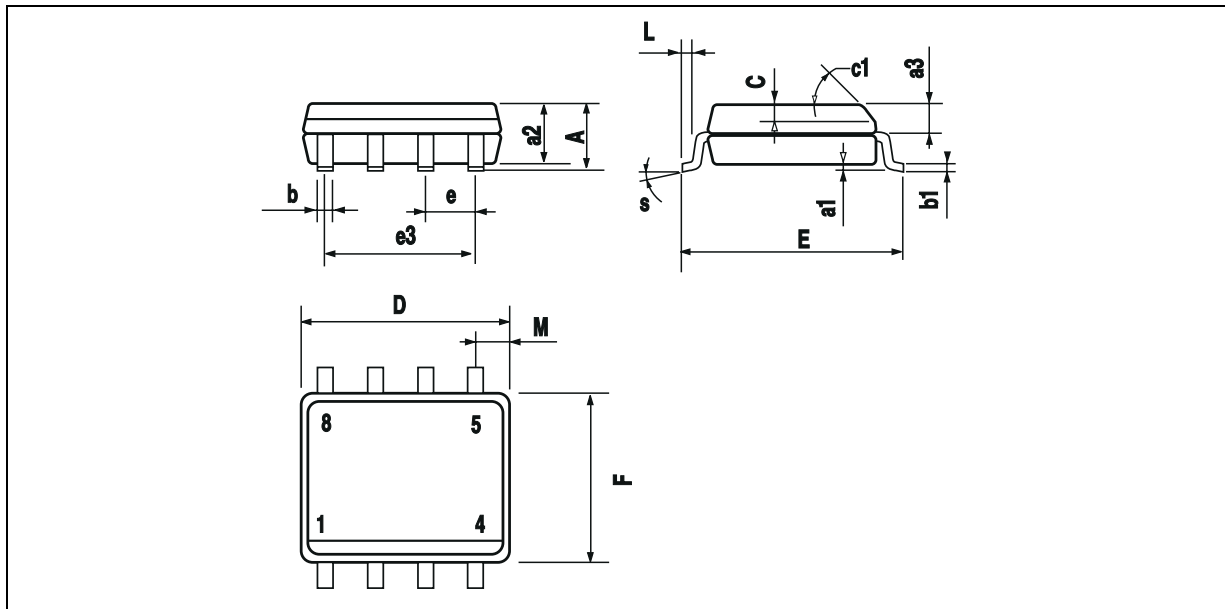


Dim.	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A		3.32			0.131	
a1	0.51			0.020		
B	1.15		1.65	0.045		0.065
b	0.356		0.55	0.014		0.022
b1	0.204		0.304	0.008		0.012
D			10.92			0.430
E	7.95		9.75	0.313		0.384
e		2.54			0.100	
e3		7.62			0.300	
e4		7.62			0.300	
F			6.6			0.260
i			5.08			0.200
L	3.18		3.81	0.125		0.150
Z			1.52			0.060

TS941ID - TS942ID

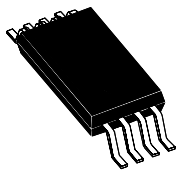
**PACKAGE MECHANICAL DATA**

8 PINS - PLASTIC MICROPACKAGE (SO)



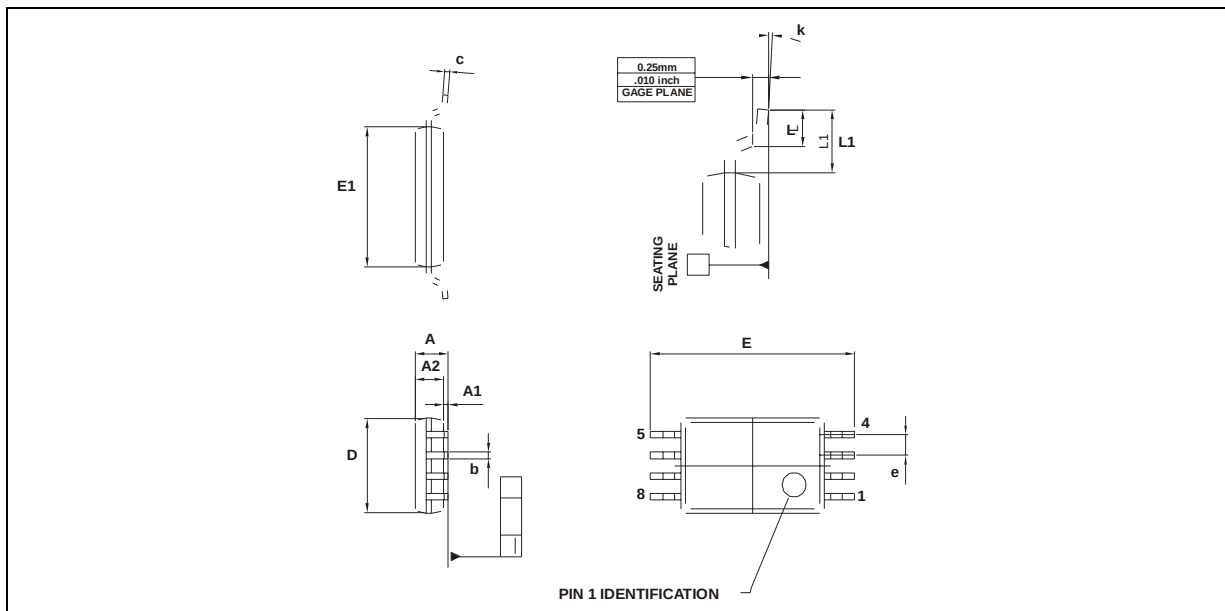
Dim.	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.75			0.069
a1	0.1		0.25	0.004		0.010
a2			1.65			0.065
a3	0.65		0.85	0.026		0.033
b	0.35		0.48	0.014		0.019
b1	0.19		0.25	0.007		0.010
C	0.25		0.5	0.010		0.020
c1	45° (typ.)					
D	4.8		5.0	0.189		0.197
E	5.8		6.2	0.228		0.244
e		1.27	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

TS942IPT



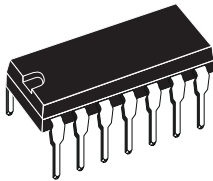
PACKAGE MECHANICAL DATA

8 PINS - THIN SHRINK SMALL OUTLINE PACKAGE

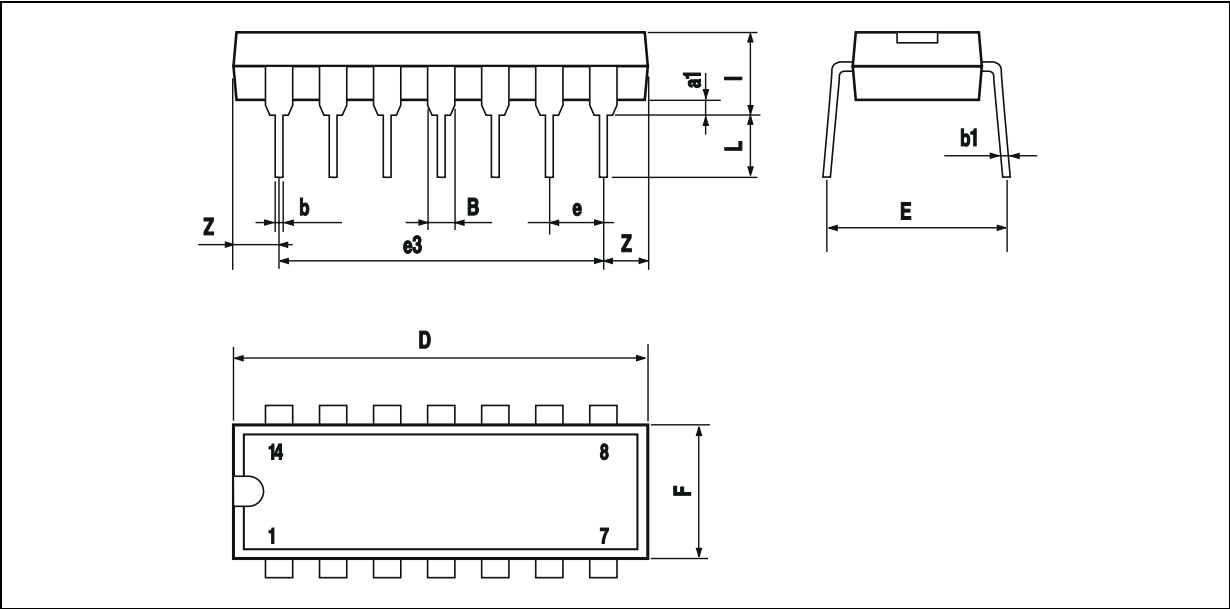


Dim.	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.20			0.05
A1	0.05		0.15	0.01		0.006
A2	0.80	1.00	1.05	0.031	0.039	0.041
b	0.19		0.30	0.007		0.15
c	0.09		0.20	0.003		0.012
D	2.90	3.00	3.10	0.114	0.118	0.122
E		6.40			0.252	
E1	4.30	4.40	4.50	0.169	0.173	0.177
e		0.65			0.025	
k	0°		8°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

TS944IN

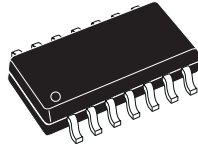


PACKAGE MECHANICAL DATA
14 PINS - PLASTIC PACKAGE

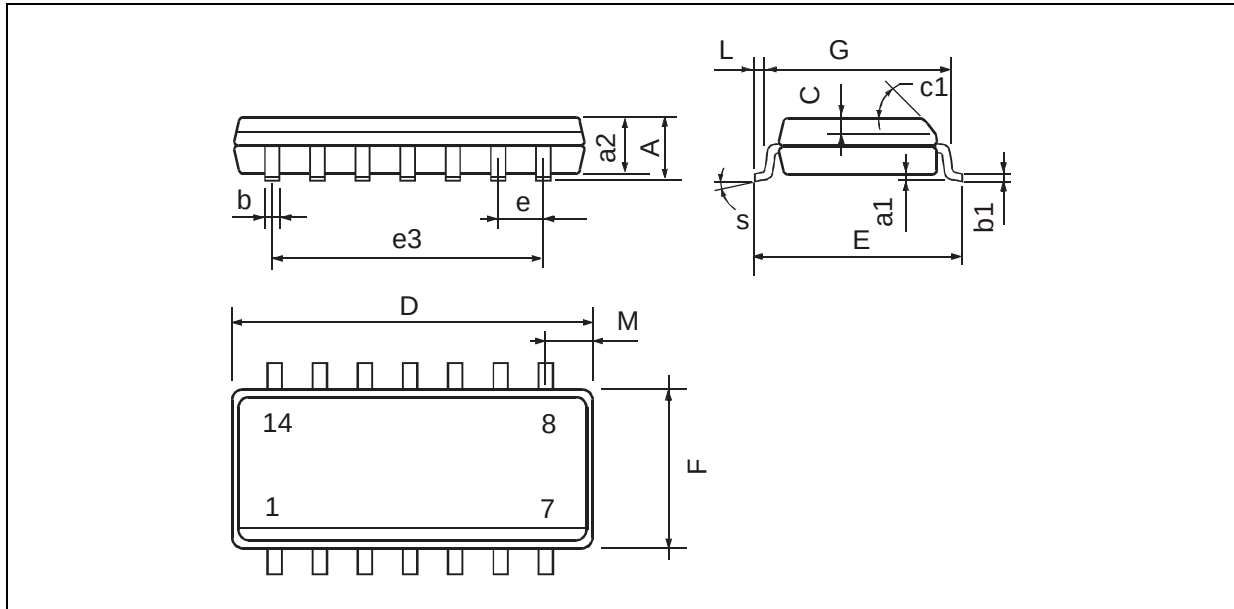


Dim.	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
a1	0.51			0.020		
B	1.39		1.65	0.055		0.065
b		0.5			0.020	
b1		0.25			0.010	
D			20			0.787
E		8.5			0.335	
e		2.54			0.100	
e3		15.24			0.600	
F			7.1			0.280
i			5.1			0.201
L		3.3			0.130	
Z	1.27		2.54	0.050		0.100

TS944ID

**PACKAGE MECHANICAL DATA**

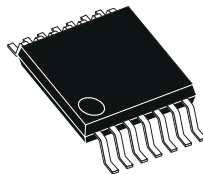
14 PINS - PLASTIC MICROPACKAGE (SO)



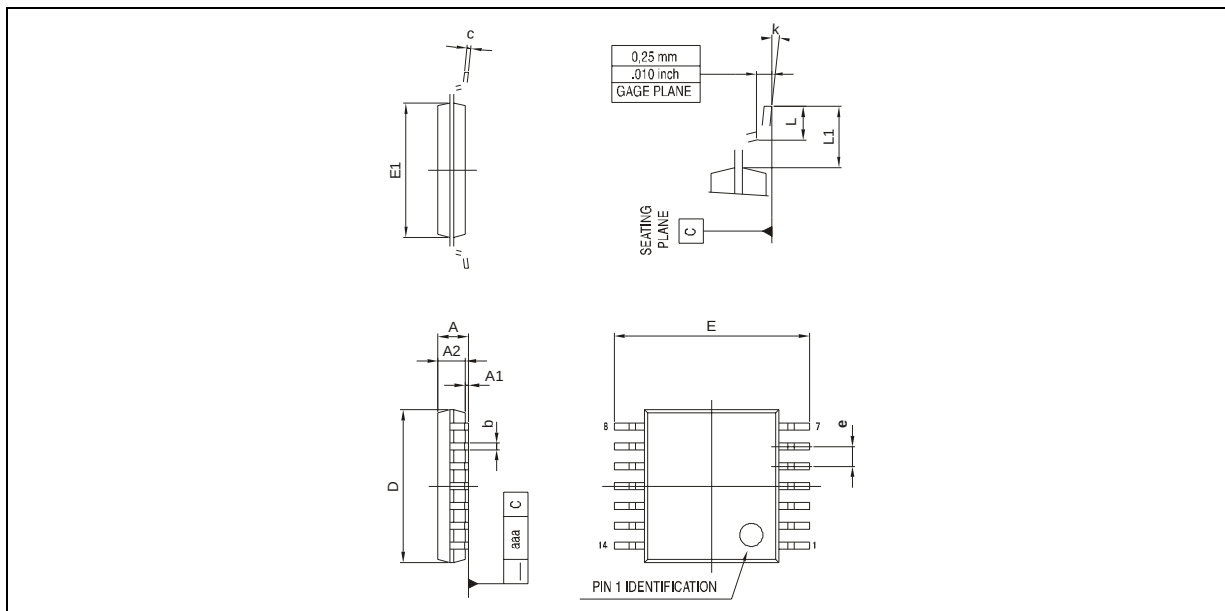
Dim.	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.75			0.069
a1	0.1		0.2	0.004		0.008
a2			1.6			0.063
b	0.35		0.46	0.014		0.018
b1	0.19		0.25	0.007		0.010
C		0.5			0.020	
c1	45° (typ.)					
D (1)	8.55		8.75	0.336		0.344
E	5.8		6.2	0.228		0.244
e		1.27			0.050	
e3		7.62			0.300	
F (1)	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.

TS944IPT

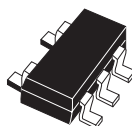
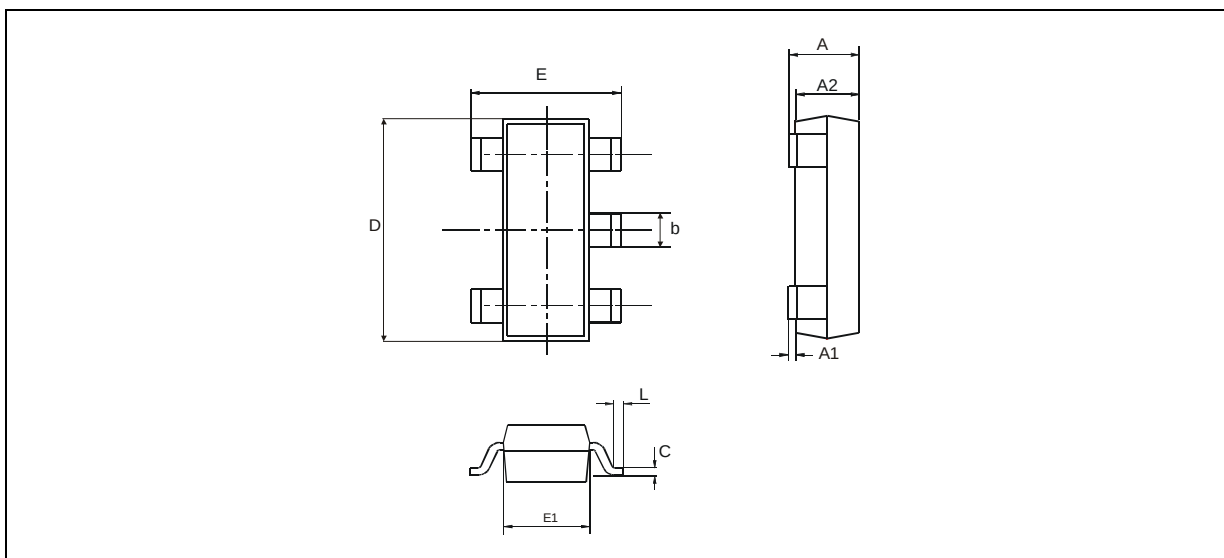
**PACKAGE MECHANICAL DATA**

14 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	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

TS941ILT


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	0.0118
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

Information furnished is believed to be accurate and reliable. However, STMicroelectronics assumes no responsibility for the consequences of use of such information nor for any infringement of patents or other rights of third parties which may result from its use. No license is granted by implication or otherwise under any patent or patent rights of STMicroelectronics. Specifications mentioned in this publication are subject to change without notice. This publication supersedes and replaces all information previously supplied. STMicroelectronics products are not authorized for use as critical components in life support devices or systems without express written approval of STMicroelectronics.

© The ST logo is a registered trademark of STMicroelectronics

© 2000 STMicroelectronics - Printed in Italy - All Rights Reserved
 STMicroelectronics GROUP OF COMPANIES

Australia - Brazil - China - Finland - France - Germany - Hong Kong - India - Italy - Japan - Malaysia - Malta - Morocco
 Singapore - Spain - Sweden - Switzerland - United Kingdom

© <http://www.st.com>