



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	•	•	•		

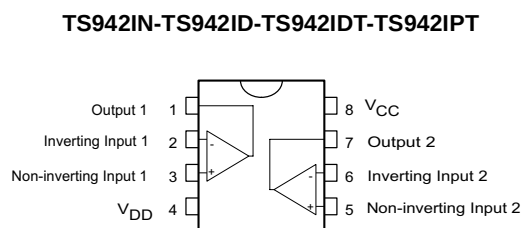
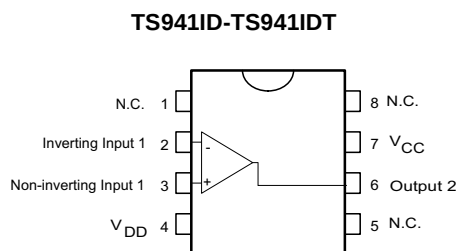
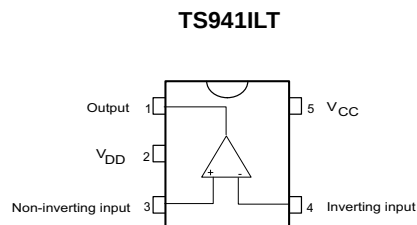
N = Dual in Line Package (DIP)

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

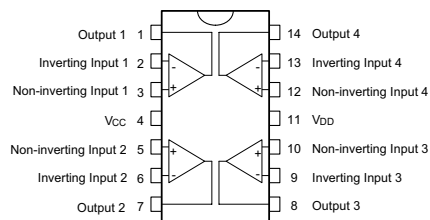
P = Thin Shrink Small Outline Package (TSSOP) - only available in Tape & Reel (PT)

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.

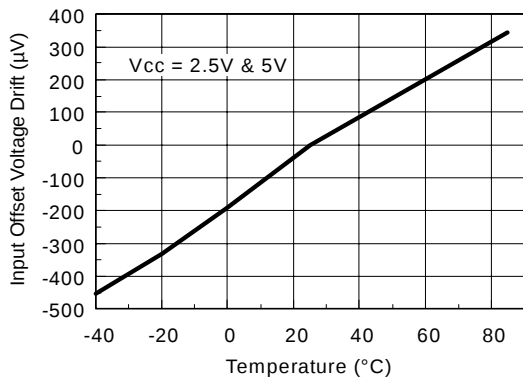
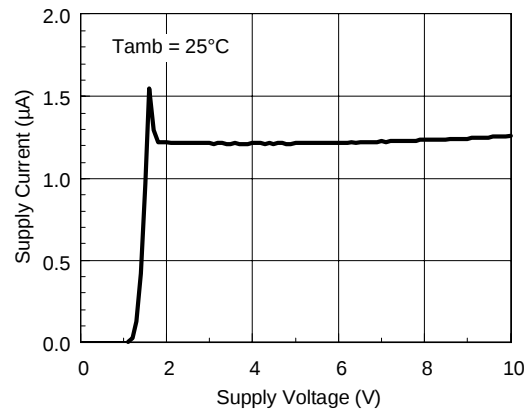
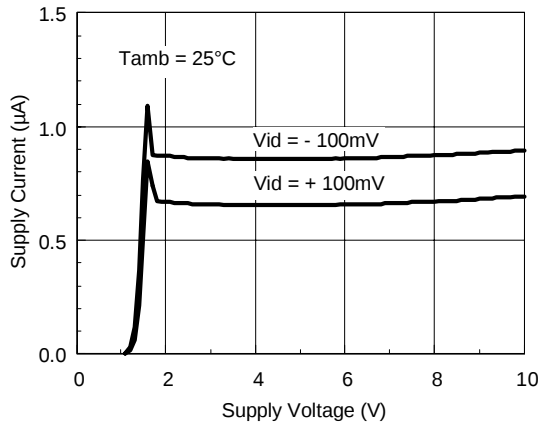
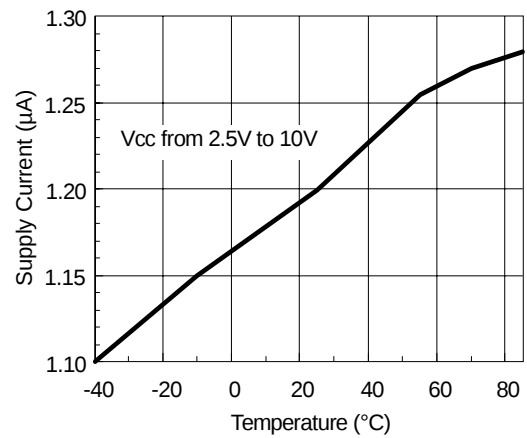
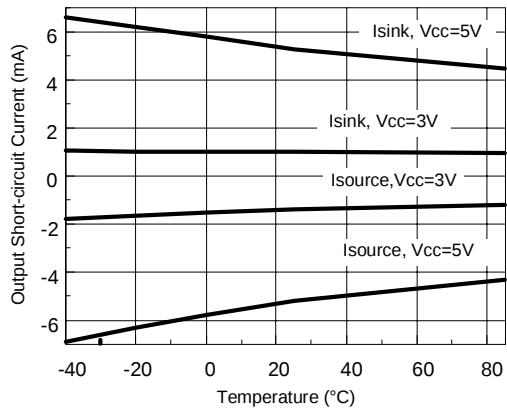
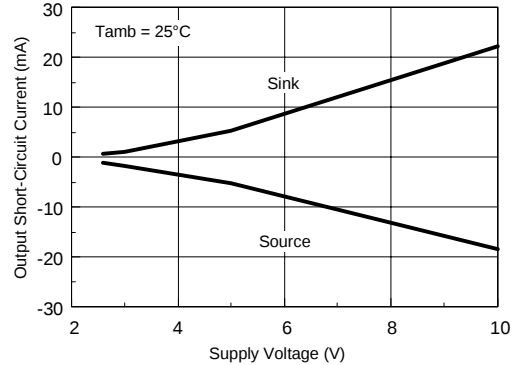
2. All electrical values are guaranteed with correlation measurements at 2.5V and 5V

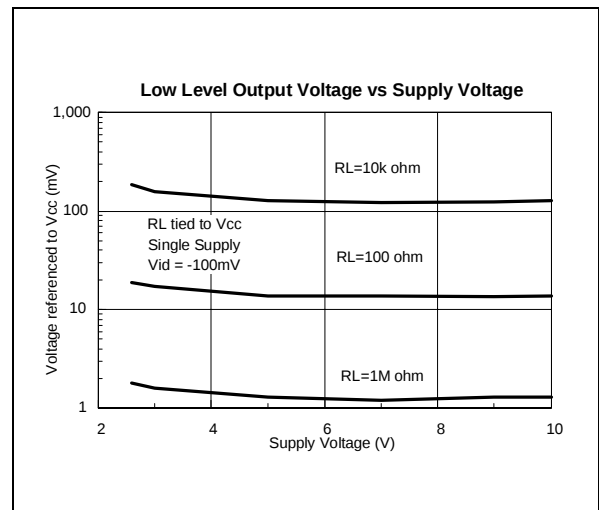
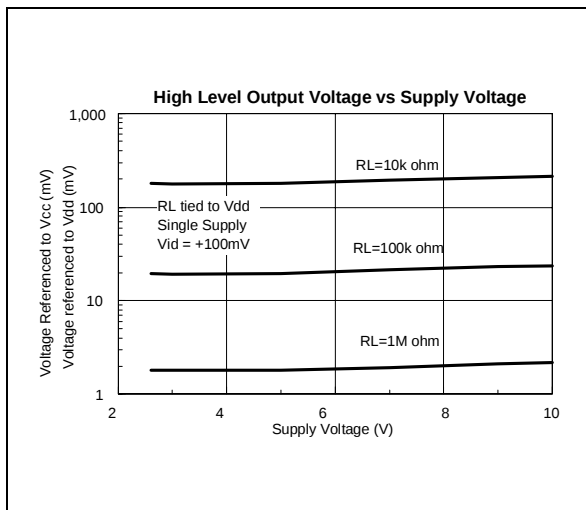
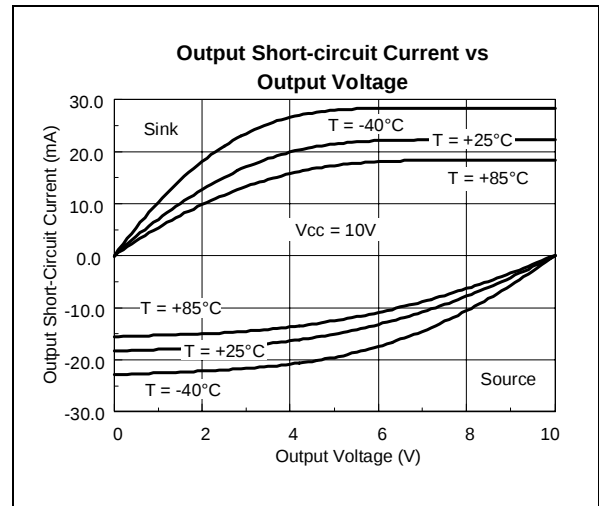
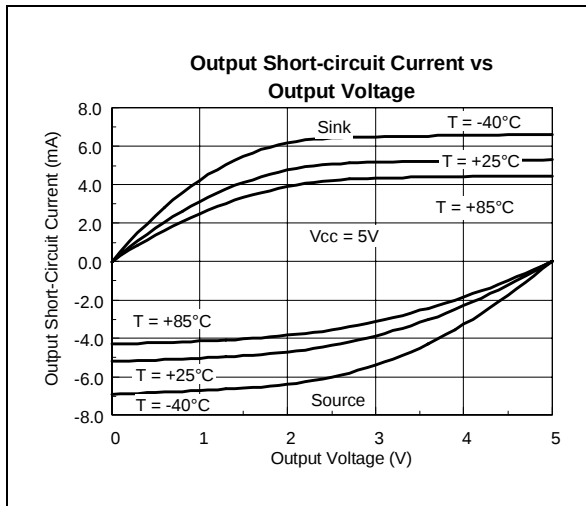
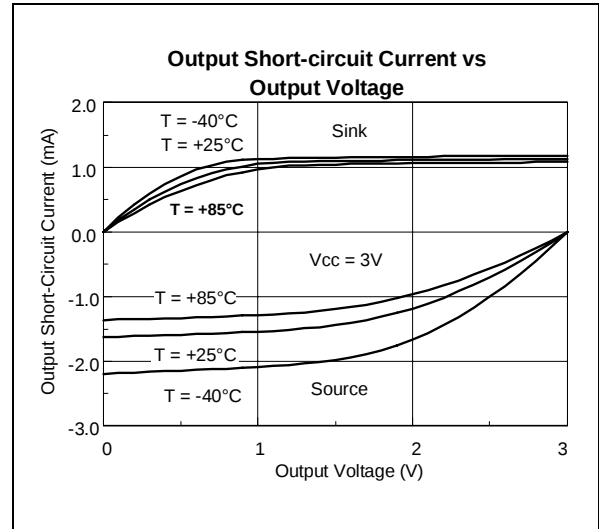
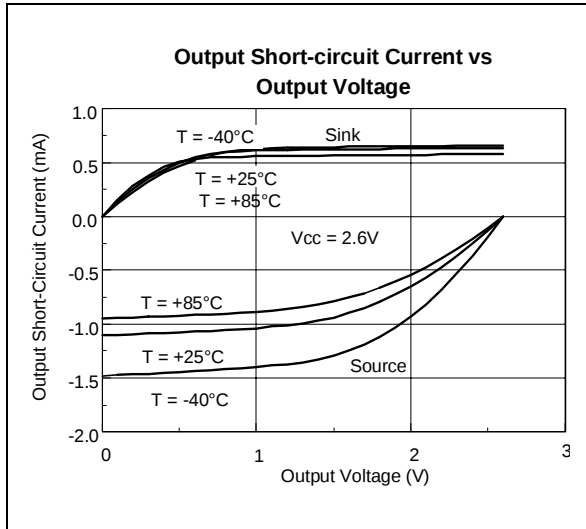
ELECTRICAL CHARACTERISTICS
 $V_{CC} = +5V$, $V_{DD} = 0V$, R_L connected to $V_{CC/2}$,

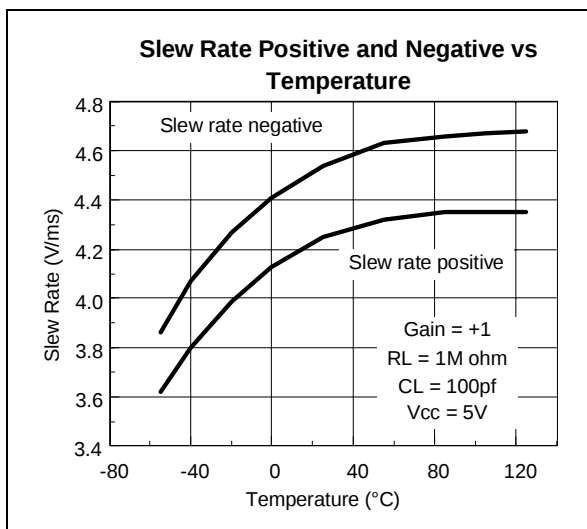
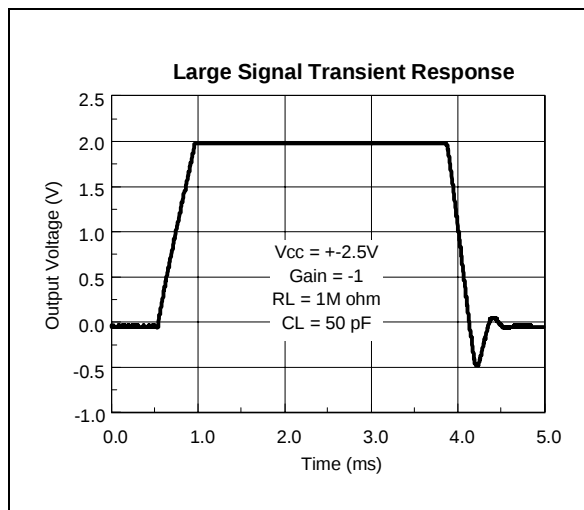
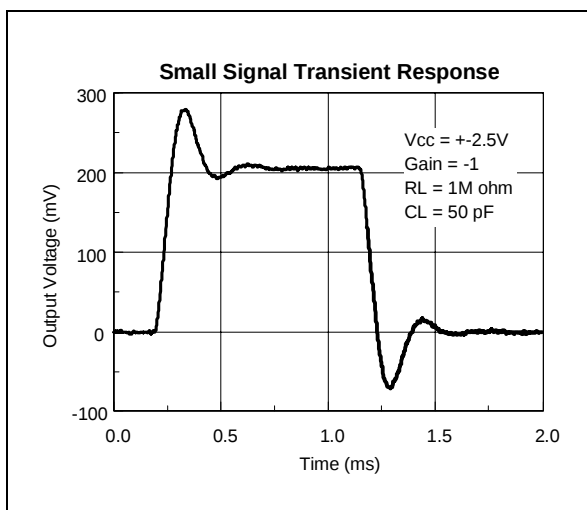
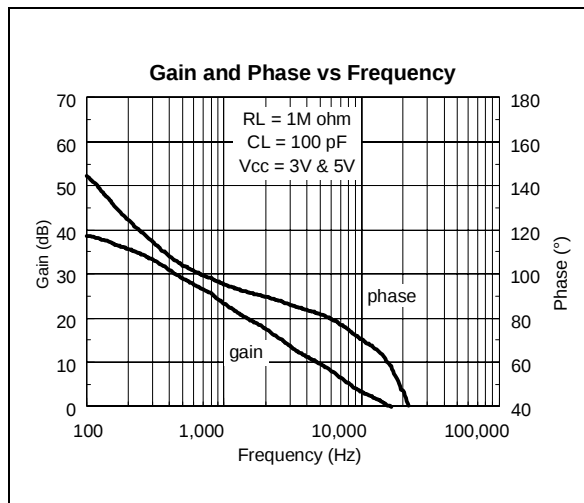
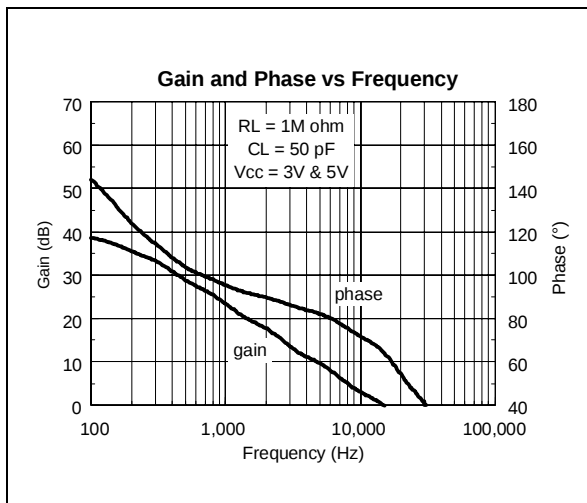
 $T_{amb} = 25^{\circ}C$ (unless otherwise specified)

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I_{io}	Input Offset Current ¹⁾		1	100	pA
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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

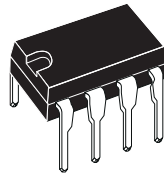
1. Maximum values including unavoidable inaccuracies of the industrial test.

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**

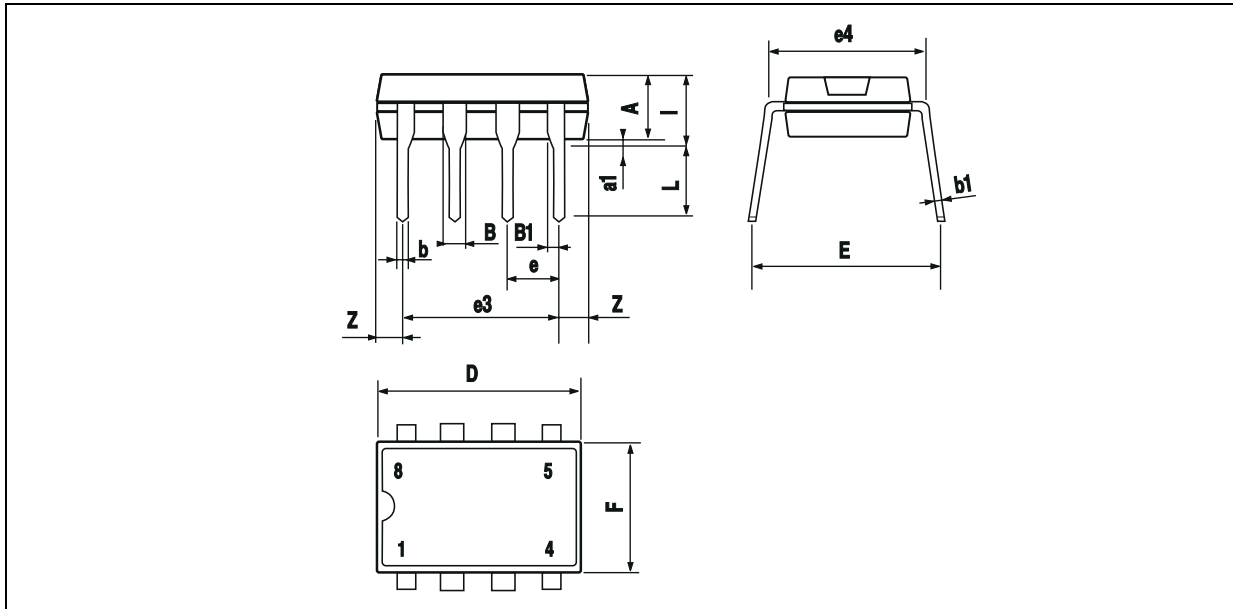




TS942IN

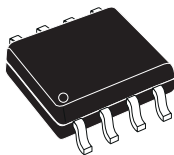


PACKAGE MECHANICAL DATA
8 PINS - PLASTIC PACKAGE

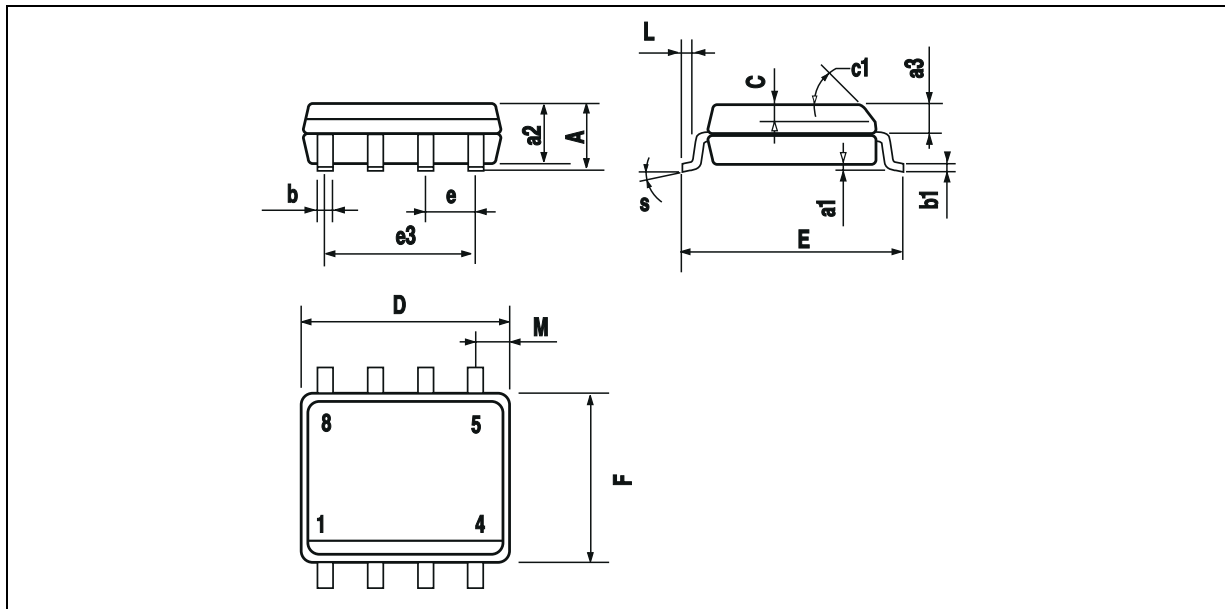


Dim.	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A		3.32			0.131	
a1	0.51			0.020		
B	1.15		1.65	0.045		0.065
b	0.356		0.55	0.014		0.022
b1	0.204		0.304	0.008		0.012
D			10.92			0.430
E	7.95		9.75	0.313		0.384
e		2.54			0.100	
e3		7.62			0.300	
e4		7.62			0.300	
F			6.6			0.260
i			5.08			0.200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

TS941ID - TS942ID

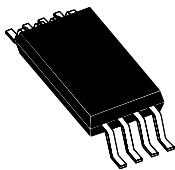
**PACKAGE MECHANICAL DATA**

8 PINS - PLASTIC MICROPACKAGE (SO)



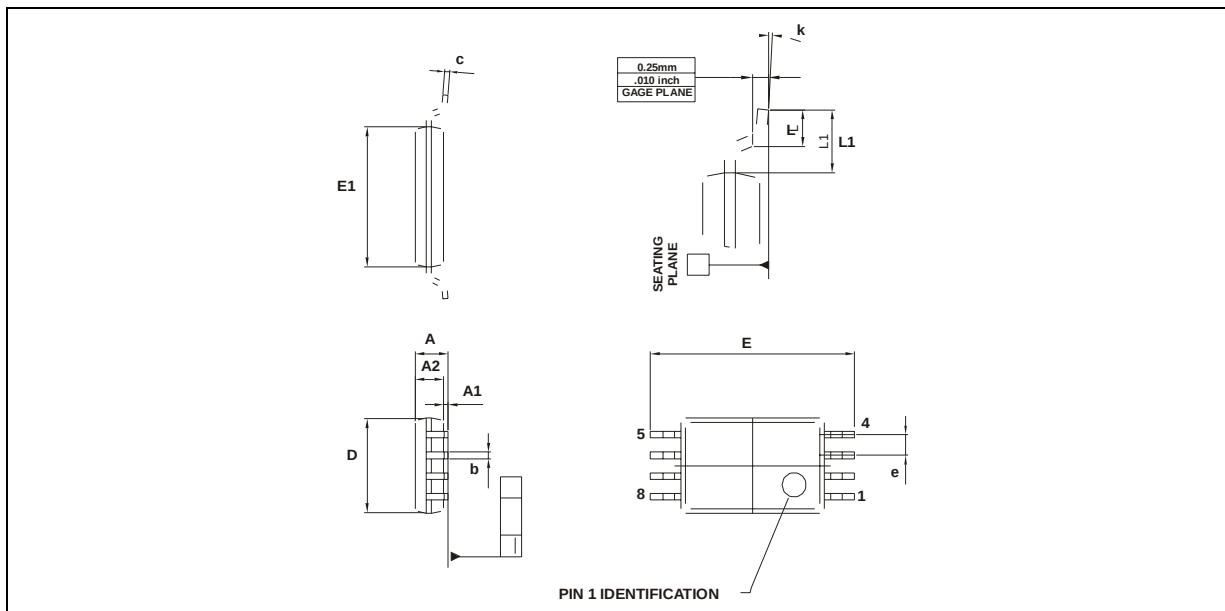
Dim.	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.75			0.069
a1	0.1		0.25	0.004		0.010
a2			1.65			0.065
a3	0.65		0.85	0.026		0.033
b	0.35		0.48	0.014		0.019
b1	0.19		0.25	0.007		0.010
C	0.25		0.5	0.010		0.020
c1	45° (typ.)					
D	4.8		5.0	0.189		0.197
E	5.8		6.2	0.228		0.244
e		1.27	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



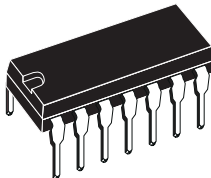
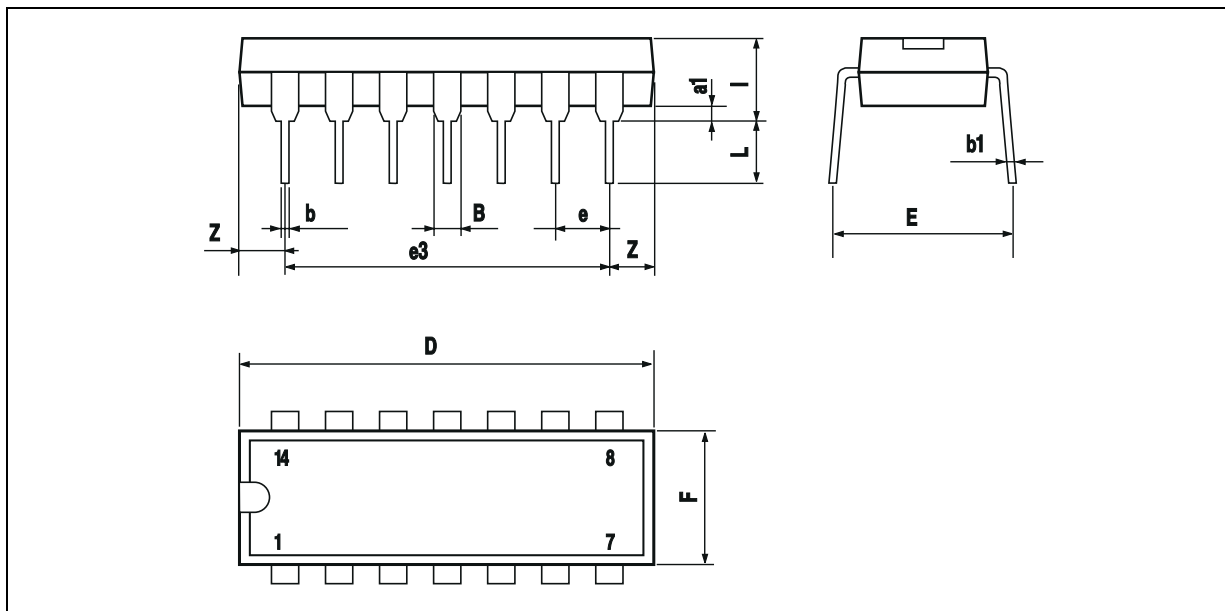
PACKAGE MECHANICAL DATA

8 PINS - THIN SHRINK SMALL OUTLINE PACKAGE



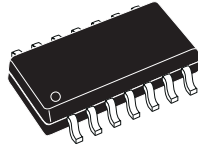
Dim.	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.20			0.05
A1	0.05		0.15	0.01		0.006
A2	0.80	1.00	1.05	0.031	0.039	0.041
b	0.19		0.30	0.007		0.15
c	0.09		0.20	0.003		0.012
D	2.90	3.00	3.10	0.114	0.118	0.122
E		6.40			0.252	
E1	4.30	4.40	4.50	0.169	0.173	0.177
e		0.65			0.025	
k	0°		8°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

TS944IN


PACKAGE MECHANICAL DATA
 14 PINS - PLASTIC PACKAGE


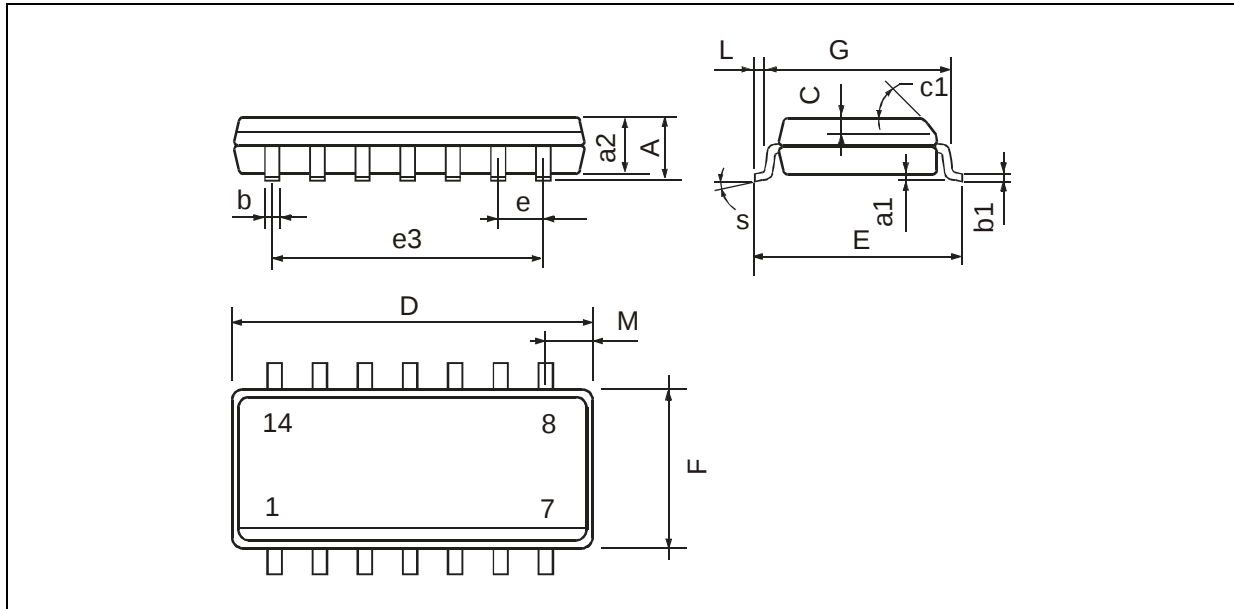
Dim.	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
a1	0.51			0.020		
B	1.39		1.65	0.055		0.065
b		0.5			0.020	
b1		0.25			0.010	
D			20			0.787
E		8.5			0.335	
e		2.54			0.100	
e3		15.24			0.600	
F			7.1			0.280
i			5.1			0.201
L		3.3			0.130	
Z	1.27		2.54	0.050		0.100

TS944ID



PACKAGE MECHANICAL DATA

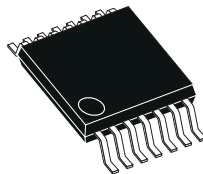
14 PINS - PLASTIC MICROPACKAGE (SO)



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.)					

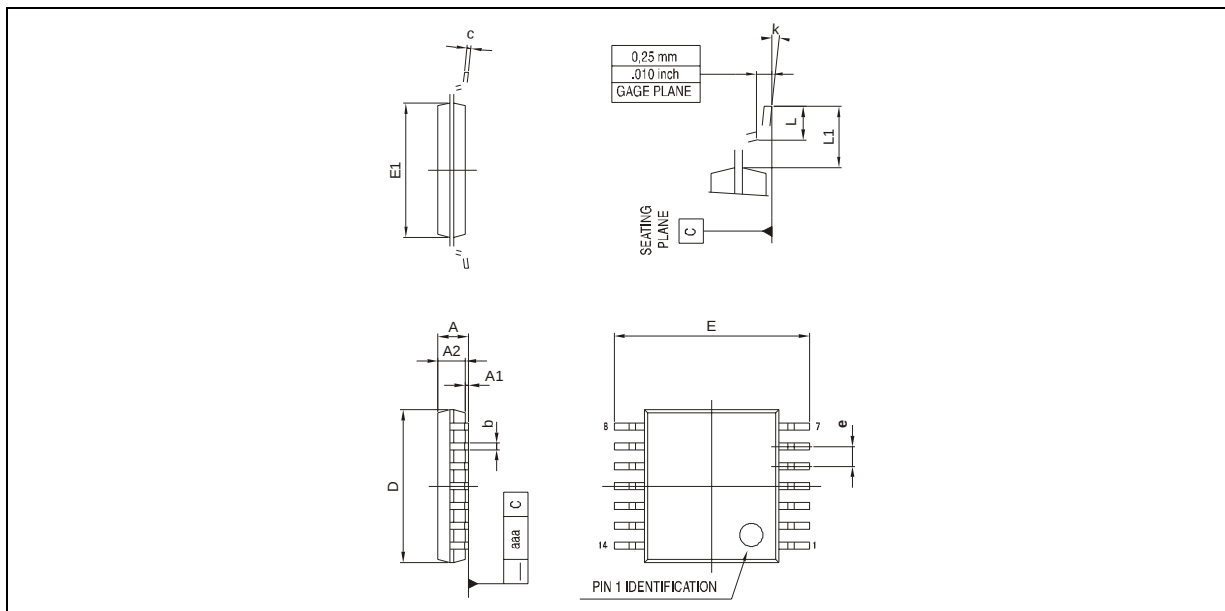
Note : (1) D and F do not include mold flash or protrusions - Mold flash or protrusions shall not exceed 0.15mm (.066 inc) ONLY FOR DATA BOOK.

TS944IPT



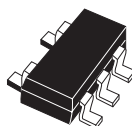
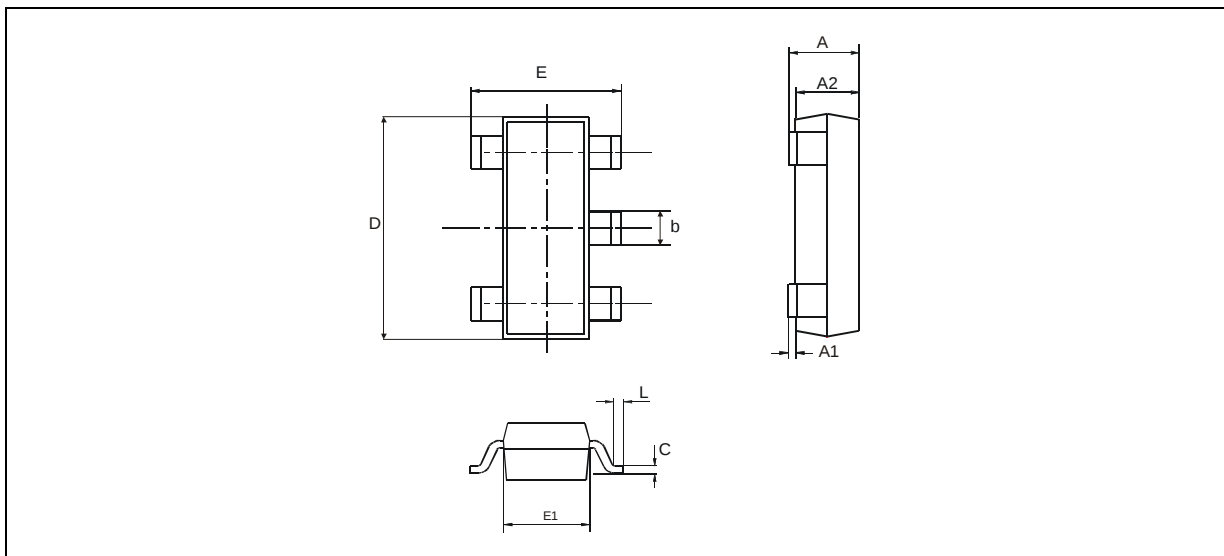
PACKAGE MECHANICAL DATA

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

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