



**TS931
TS932
TS934**

OUTPUT RAIL TO RAIL MICROPOWER OPERATIONAL AMPLIFIERS

- RAIL TO RAIL **OUTPUT VOLTAGE SWING**
- **MICROPOWER CONSUMPTION (20µA)**
- **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) is Operational Amplifier 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 20µA, it is particularly well-suited for every kind of battery-supplied applications.

The TS93x is housed in the space-saving 5 pins SOT23-5 package which simplifies the board design because of the ability to be placed everywhere (outside dimensions are : 2.8mm x 2.9mm).

APPLICATION

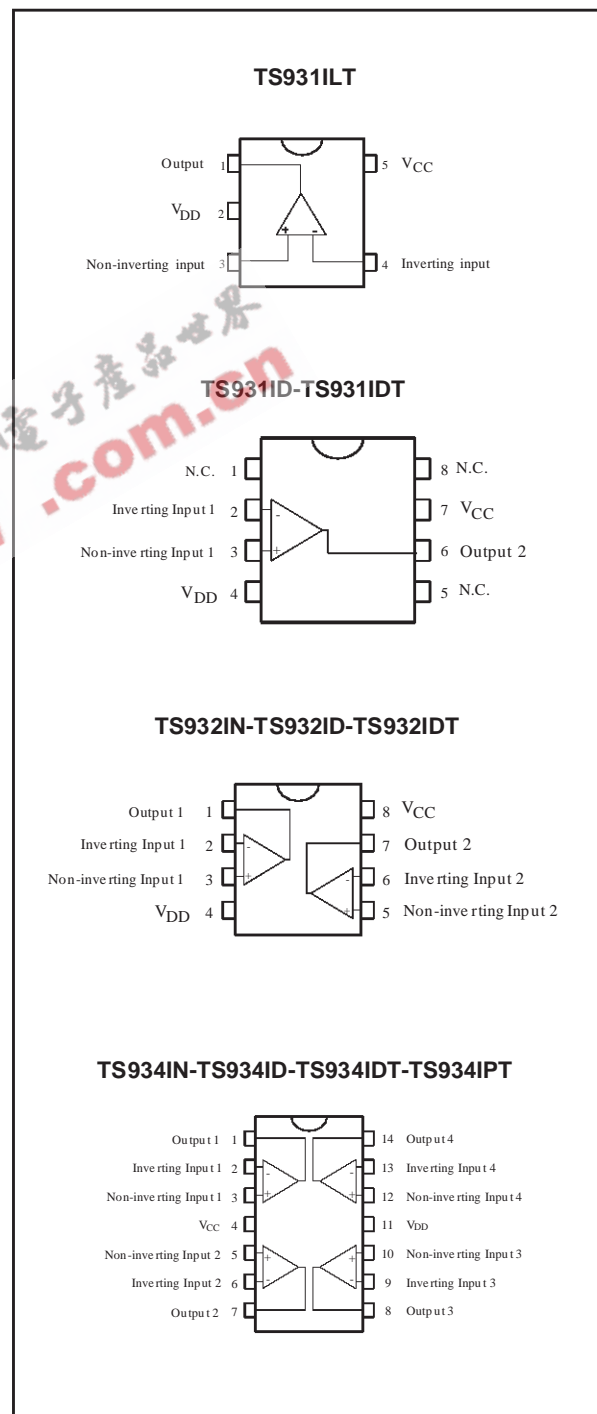
- Battery-powered systems
- Portable communication systems
- Alarm, smoke detectors
- Instrumentation & sensing
- PH Meter
- Digital scales

ORDER CODE

| Part Number | Temperature Range | Package | | | | SOT23 Marking |
|---------------------|-------------------|---------|---|---|---|------------------|
| | | N | D | P | L | |
| TS931I TS931A/BI | -40, +85°C | | • | | • | K205 K206/207 |
| TS932I TS932A/BI | -40, +85°C | • | • | | | |
| TS934I TS934A/BI | -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)



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⁾ | | °C/W |
| | SOT23-5 | 81 | |
| | DIP8 | 42 | |
| | DIP14 | 32 | |
| | SO8 | 28 | |
| | SO14 | 22 | |
| | TSSOP8 | 26 | |
| | TSSOP14 | 21 | |
| 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) | 260 | °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 | 2.7 to 10 | V |
| V_{icm} | Common Mode Input Voltage Range | $V_{ee} - 0.2$ to $V_{CC} - 1.5$ | V |

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ELECTRICAL CHARACTERISTICS

$V_{CC} = +3V$, $V_{EE} = 0V$,

$T_{amb} = 25^{\circ}C$ (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 |
| ΔV_{io} | Input Offset Voltage Drift | | 3 | | $\mu V/^{\circ}C$ |
| I_{io} | Input Offset Current ¹⁾ | | 1 | 100 | pA |
| I_{ib} | Input Bias Current ¹⁾ | | 1 | 150 | pA |
| CMR | Common Mode Rejection Ratio $0 \leq V_{icm} \leq V_{CC} - 1.7$ | | 85 | | dB |
| SVR | Supply Voltage Rejection Ratio ²⁾ | | 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 | μA |
| 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 |
| ϕ_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.

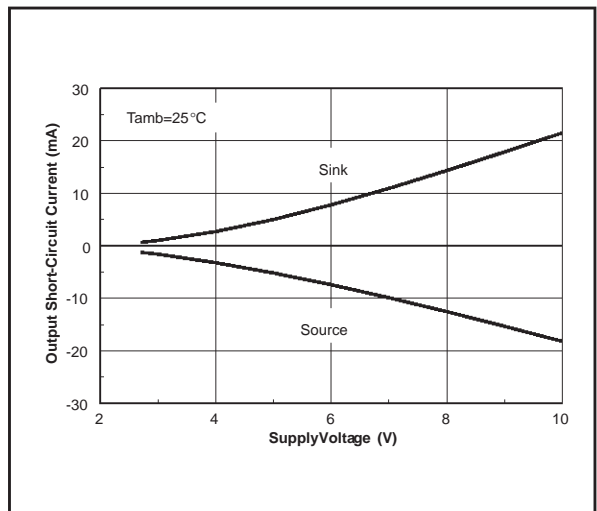
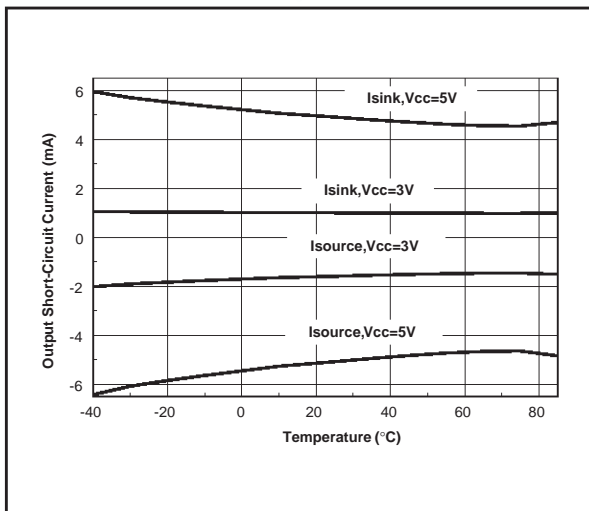
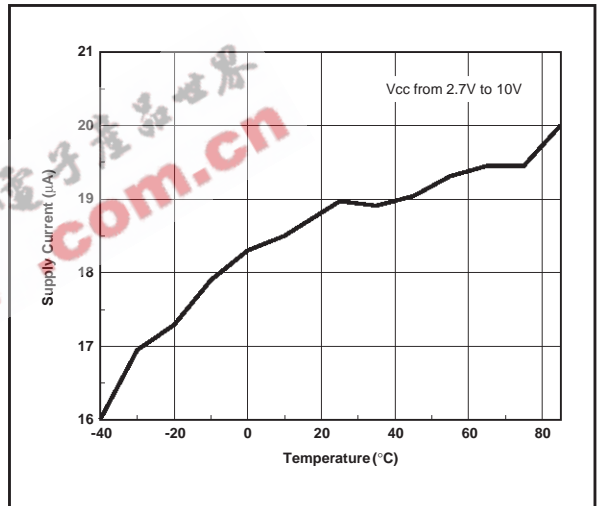
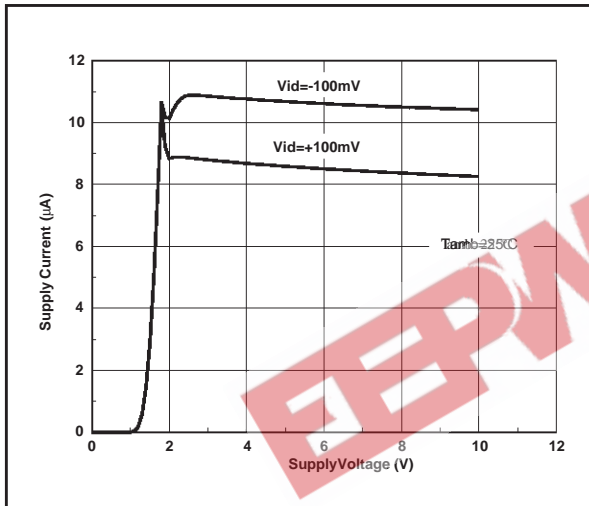
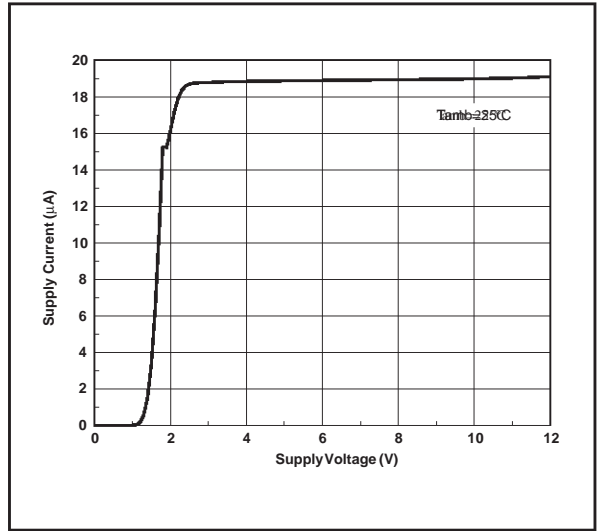
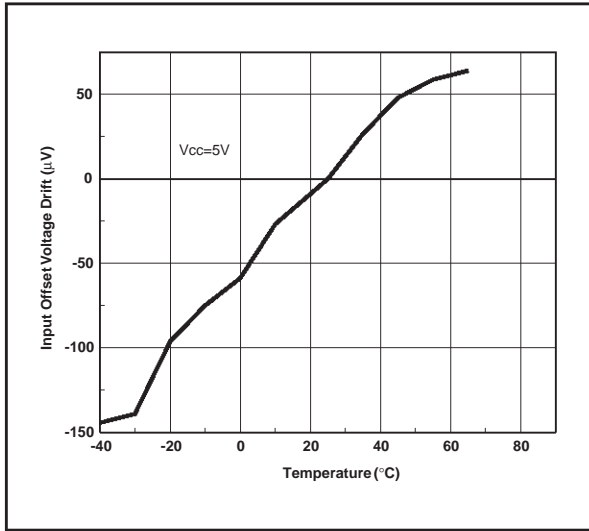
ELECTRICAL CHARACTERISTICS $V_{CC} = +5V$, $V_{EE} = 0V$, $T_{amb} = 25^{\circ}C$ (unless otherwise specified)

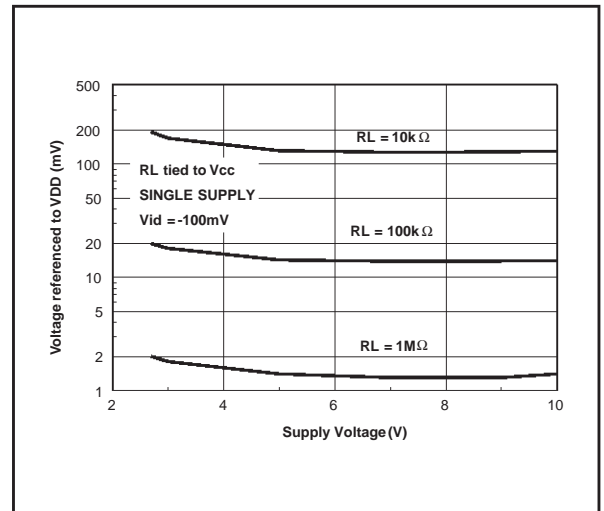
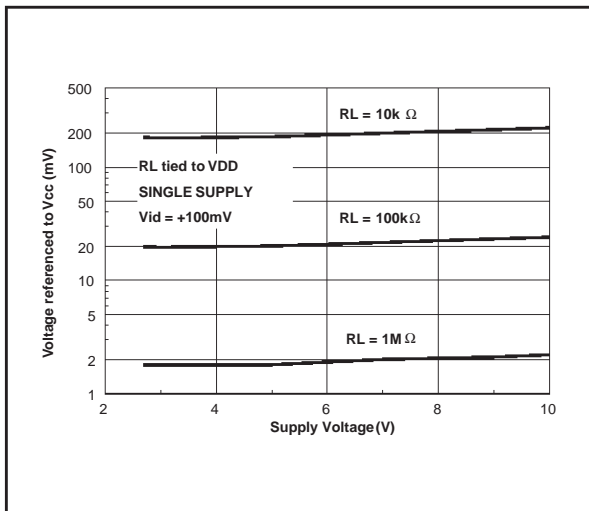
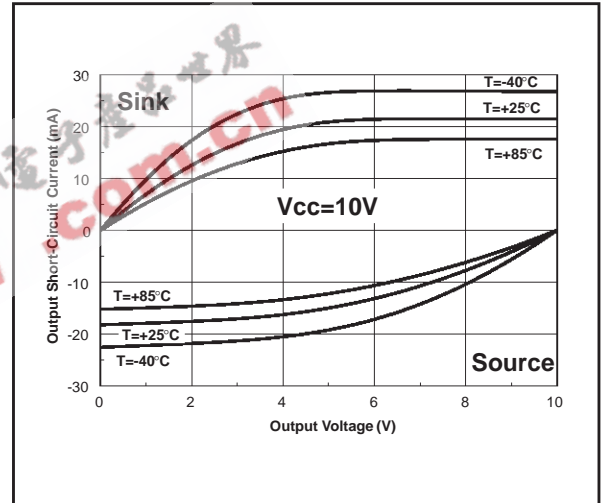
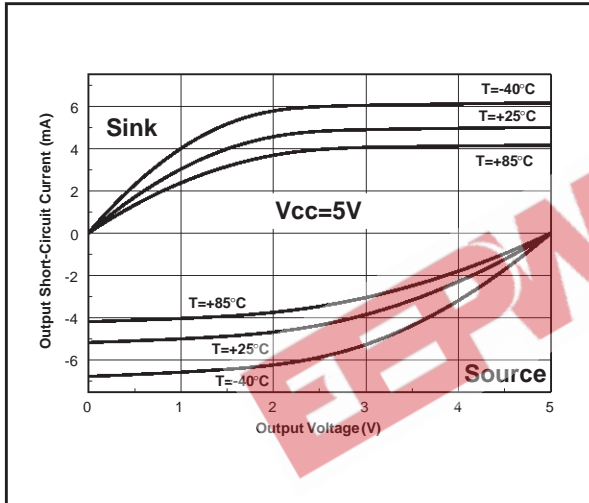
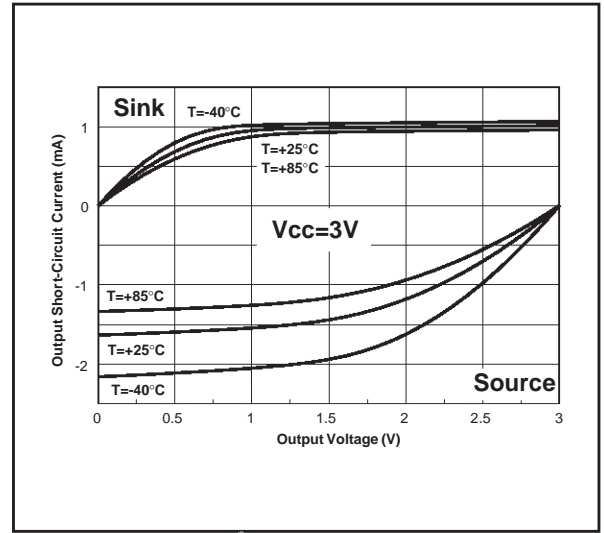
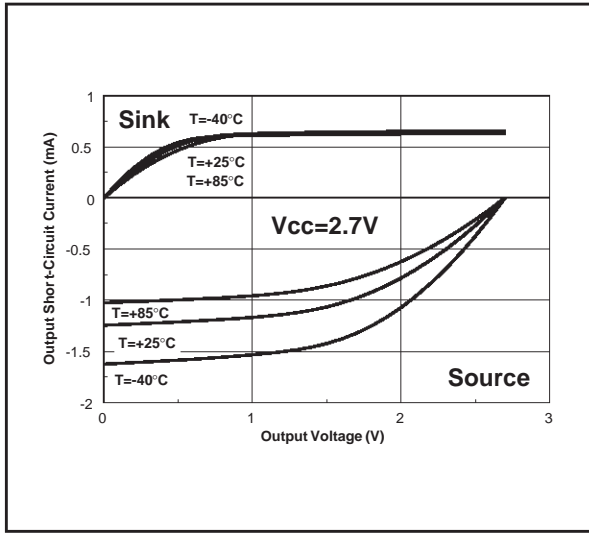
| Symbol | Parameter | Min. | Typ. | Max. | Unit |
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| ΔV_{io} | Input Offset Voltage Drift | | 3 | | $\mu V/^{\circ}C$ |
| I_{io} | Input Offset Current ¹⁾ | | 1 | 100 | pA |
| I_{ib} | Input Bias Current ¹⁾ | | 1 | 150 | pA |
| CMR | Common Mode Rejection Ratio $0 \leq V_{icm} \leq V_{CC} - 1.7$ | | 85 | | dB |
| SVR | Supply Voltage Rejection Ratio ²⁾ | | 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 | μA |
| 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 |
| ϕ_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.

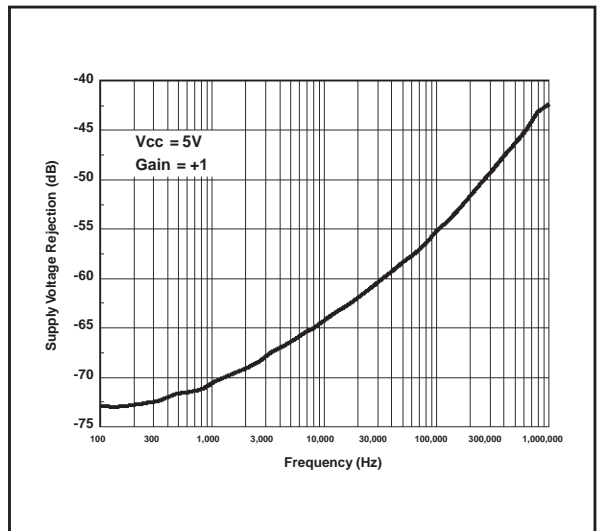
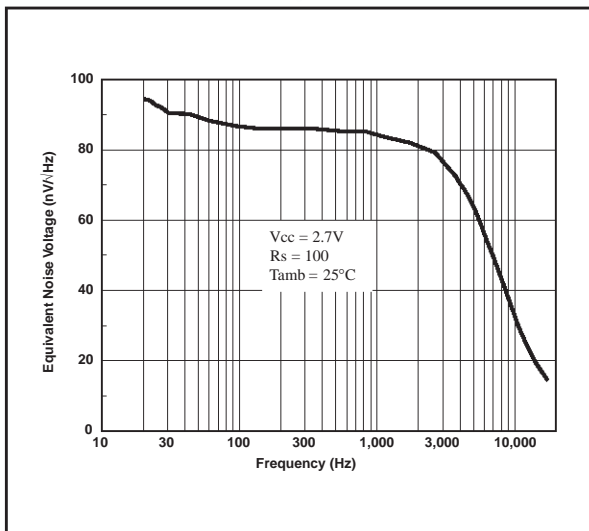
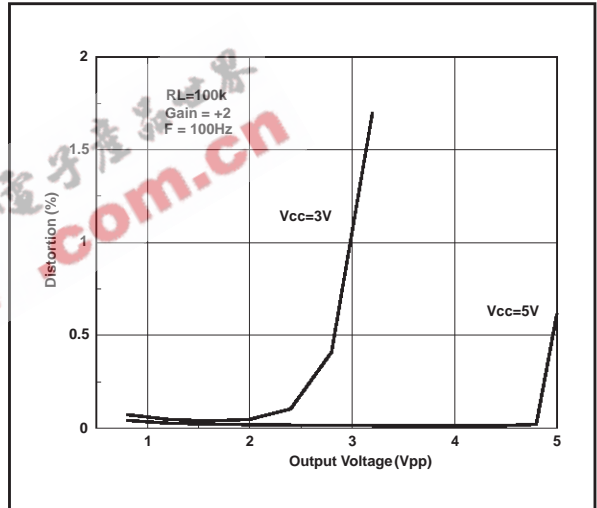
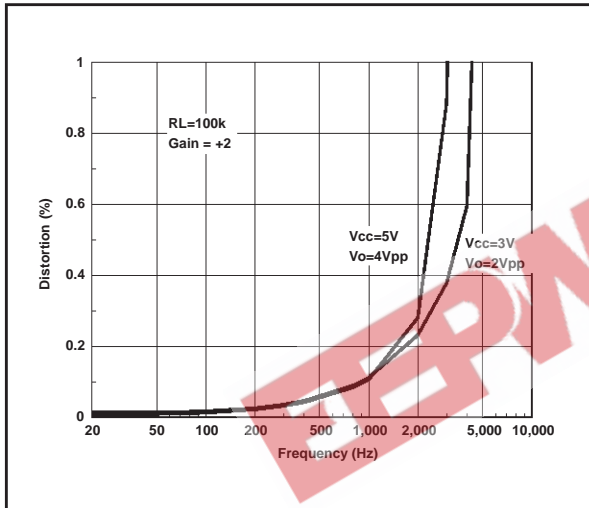
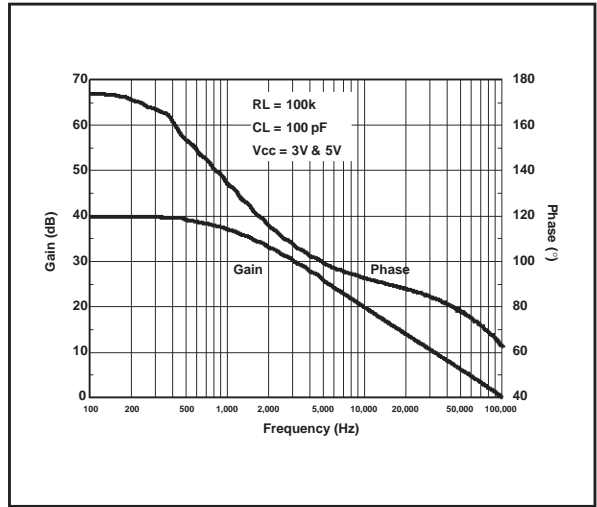
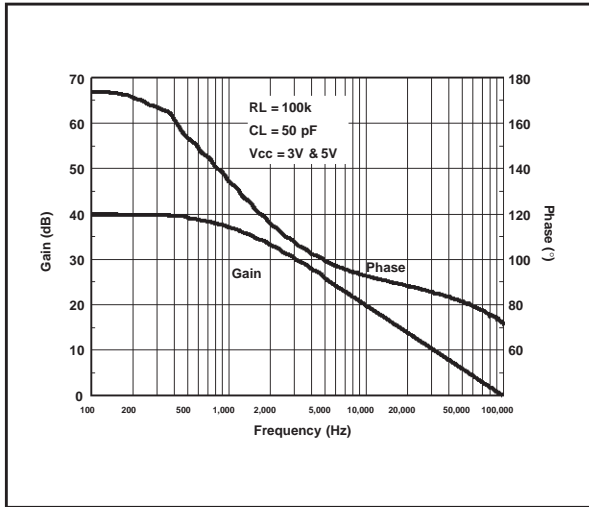
2. V_{CC} has a 0.2V variation.

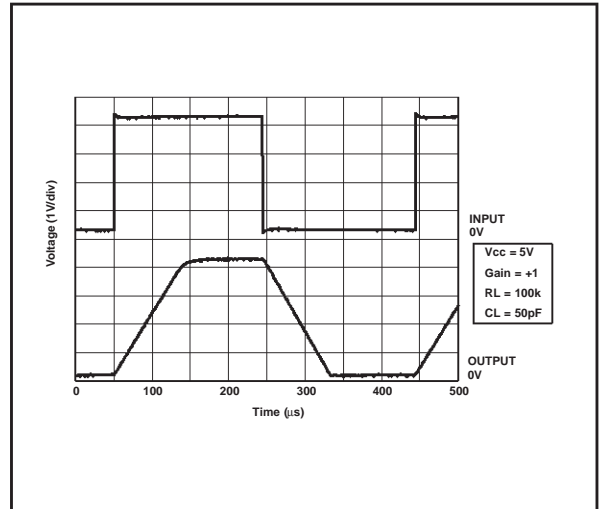
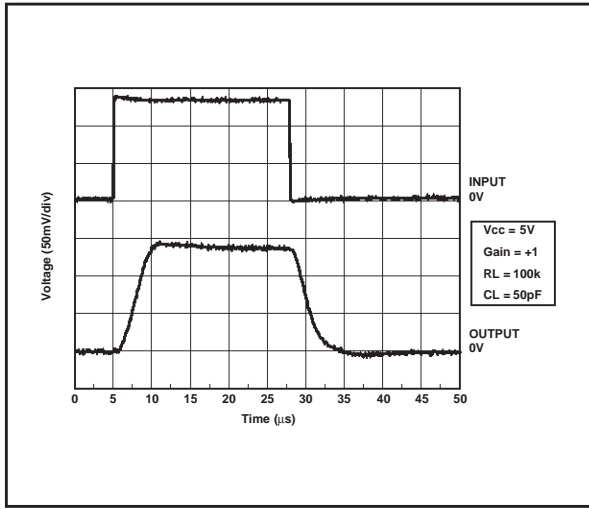
TS931-TS932-TS934





TS931-TS932-TS934

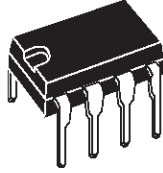




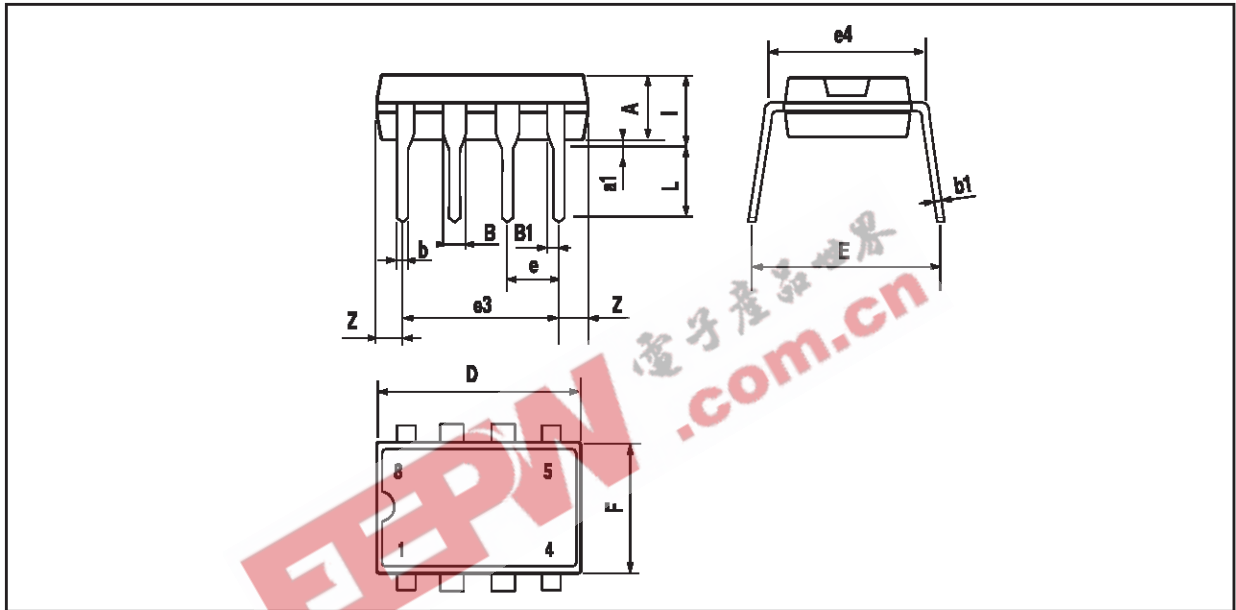
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TS932IN

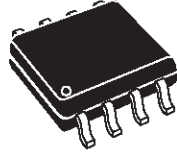


PACKAGE MECHANICAL DATA
8 PINS - PLASTIC PACKAGE

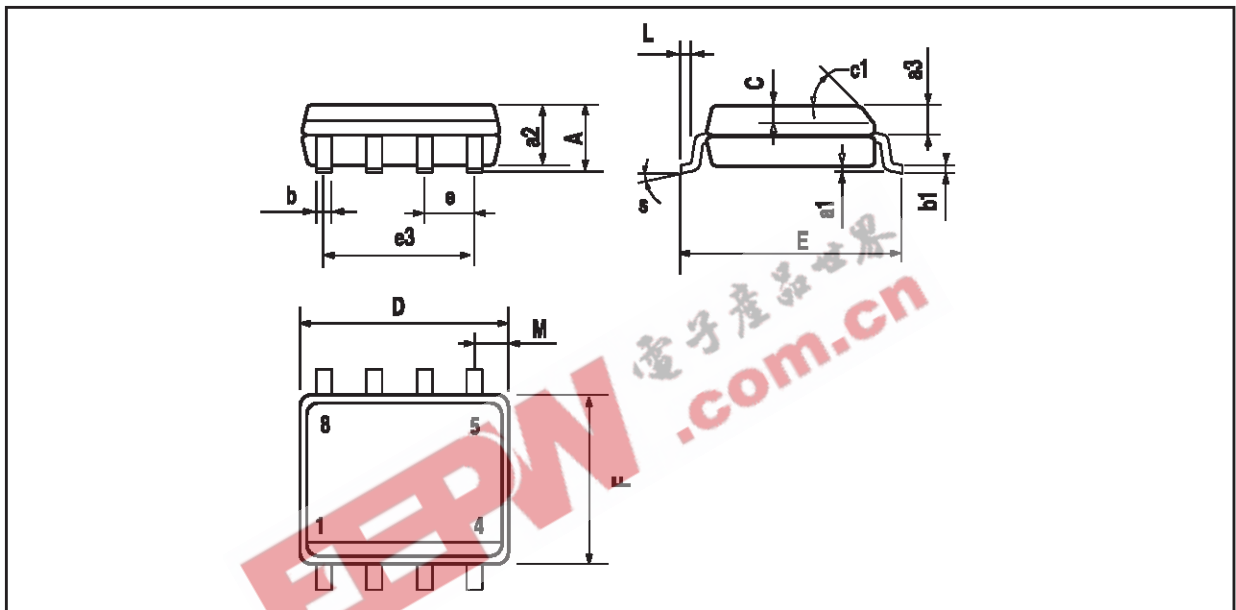


| Dim. | Millimeters | | | Inches | | |
|------|-------------|------|-------|--------|-------|-------|
| | Min. | Typ. | Max. | Min. | Typ. | Max. |
| A | | 3.32 | | | 0.131 | |
| a1 | 0.51 | | | 0.020 | | |
| B | 1.15 | | 1.65 | 0.045 | | 0.065 |
| b | 0.356 | | 0.55 | 0.014 | | 0.022 |
| b1 | 0.204 | | 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 |

TS931ID - TS932ID



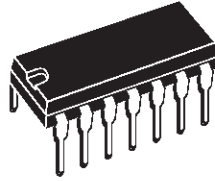
PACKAGE MECHANICAL DATA
8 PINS - PLASTIC MICROPACKAGE (SO)



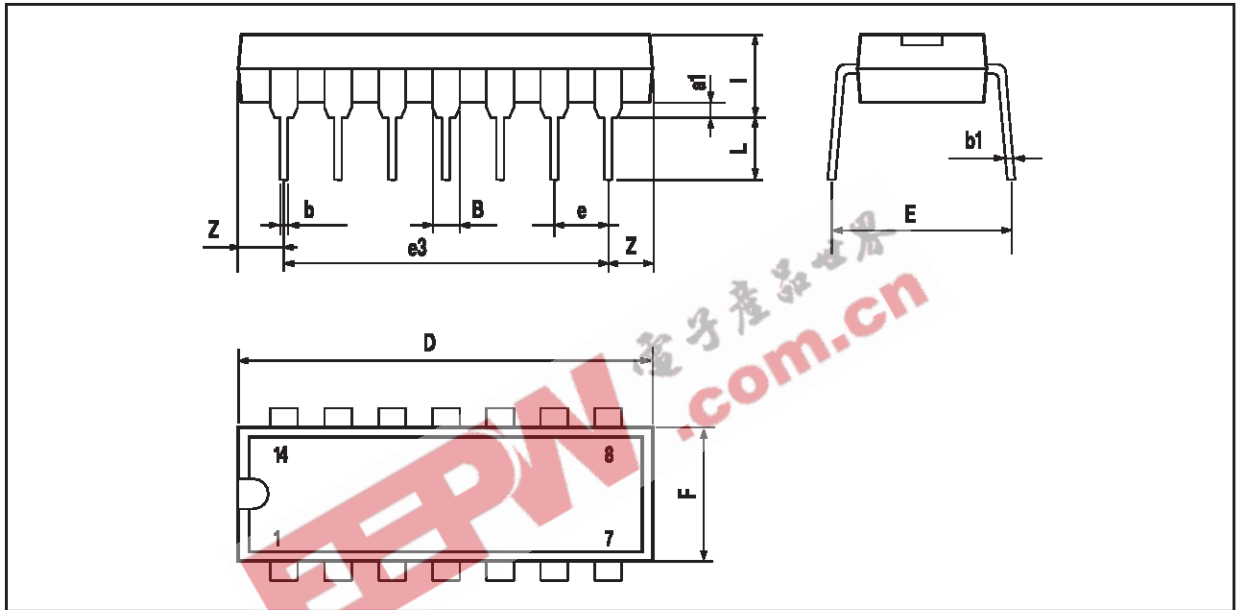
| Dim. | Millimeters | | | Inches | | |
|------|-------------|------|------|--------|-------|-------|
| | Min. | Typ. | Max. | Min. | Typ. | Max. |
| A | | | 1.75 | | | 0.069 |
| a1 | 0.1 | | 0.25 | 0.004 | | 0.010 |
| a2 | | | 1.65 | | | 0.065 |
| a3 | 0.65 | | 0.85 | 0.026 | | 0.033 |
| b | 0.35 | | 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.) | | | | | |

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TS934IN

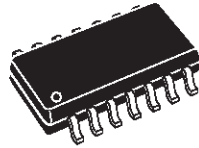


PACKAGE MECHANICAL DATA
14 PINS - PLASTIC PACKAGE

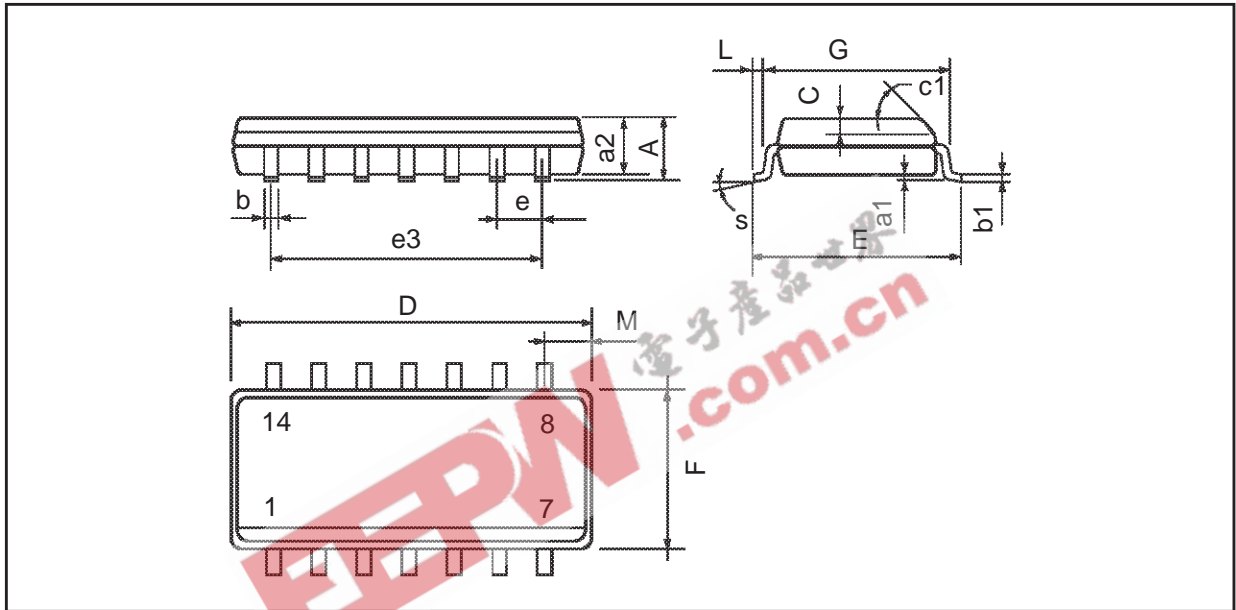


| Dim. | Millimeters | | | Inches | | |
|------|-------------|-------|------|--------|-------|-------|
| | Min. | Typ. | Max. | Min. | Typ. | Max. |
| a1 | 0.51 | | | 0.020 | | |
| B | 1.39 | | 1.65 | 0.055 | | 0.065 |
| b | | 0.5 | | | 0.020 | |
| b1 | | 0.25 | | | 0.010 | |
| D | | | 20 | | | 0.787 |
| 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 |

TS934ID



PACKAGE MECHANICAL DATA
14 PINS - PLASTIC MICROPACKAGE (SO)

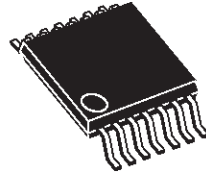


| Dim. | Millimeters | | | Inches | | |
|-------|-------------|------|------|--------|-------|-------|
| | Min. | Typ. | Max. | Min. | Typ. | Max. |
| A | | | 1.75 | | | 0.069 |
| a1 | 0.1 | | 0.2 | 0.004 | | 0.008 |
| a2 | | | 1.6 | | | 0.063 |
| b | 0.35 | | 0.46 | 0.014 | | 0.018 |
| b1 | 0.19 | | 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.

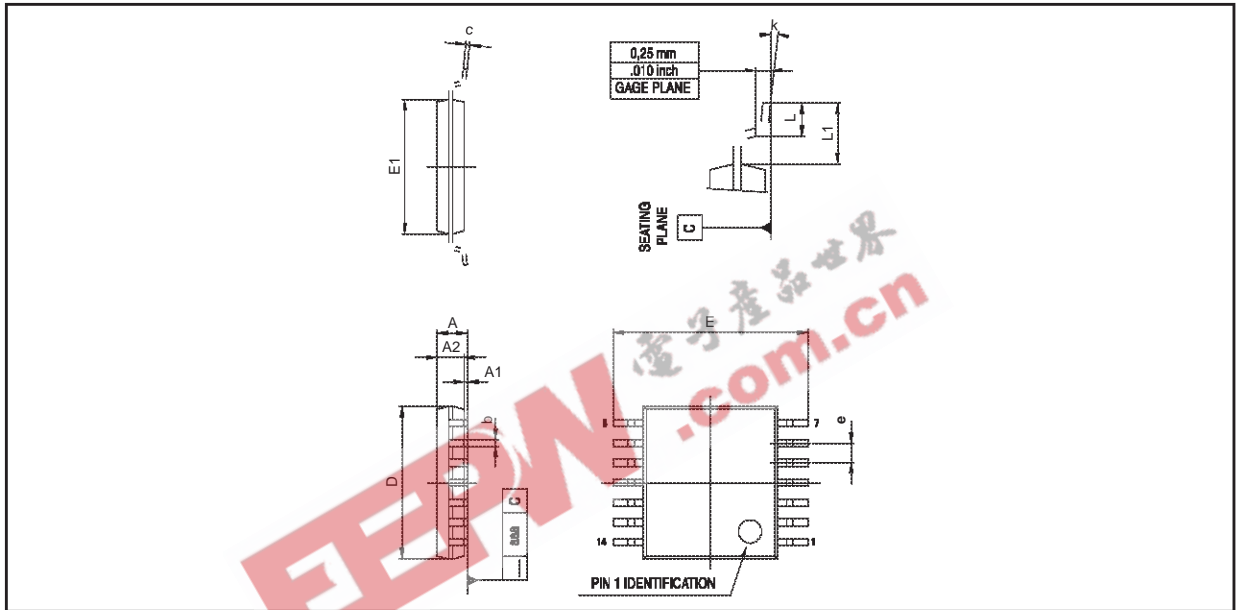
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TS934IPT



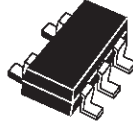
PACKAGE MECHANICAL DATA

14 PINS - THIN SHRINK SMALL OUTLINE PACKAGE

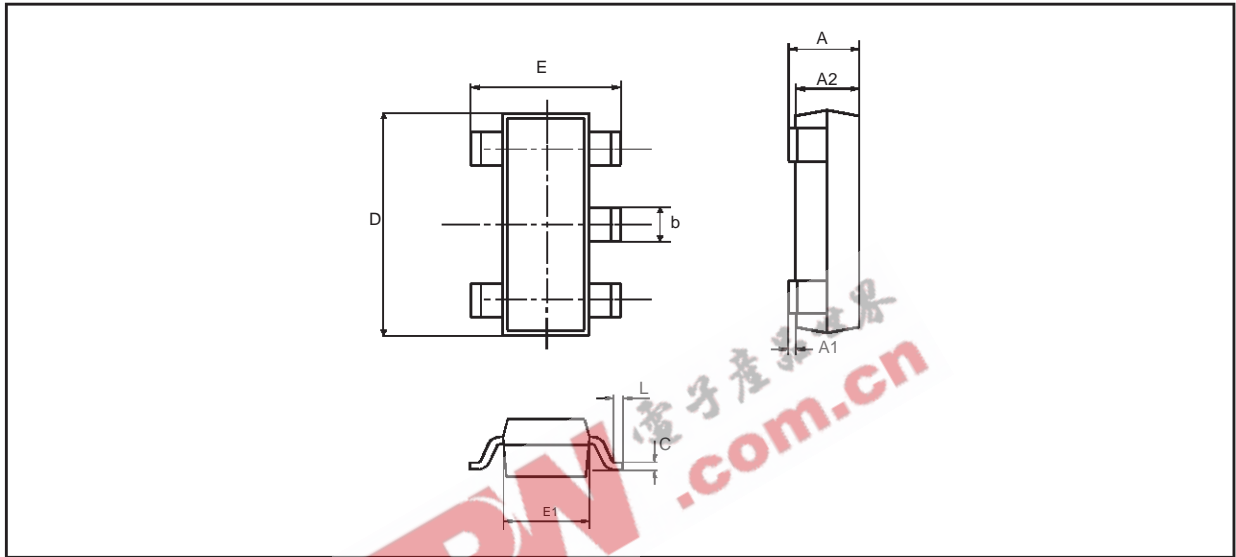


| Dim. | Millimeters | | | Inches | | |
|------|-------------|------|------|--------|--------|-------|
| | Min. | Typ. | Max. | Min. | Typ. | Max. |
| A | | | 1.20 | | | 0.05 |
| A1 | 0.05 | | 0.15 | 0.01 | | 0.006 |
| A2 | 0.80 | 1.00 | 1.05 | 0.031 | 0.039 | 0.041 |
| b | 0.19 | | 0.30 | 0.007 | | 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 |

TS931ILT



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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