



**TS931  
TS932  
TS934**

## 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) 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 20 $\mu$ A, 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

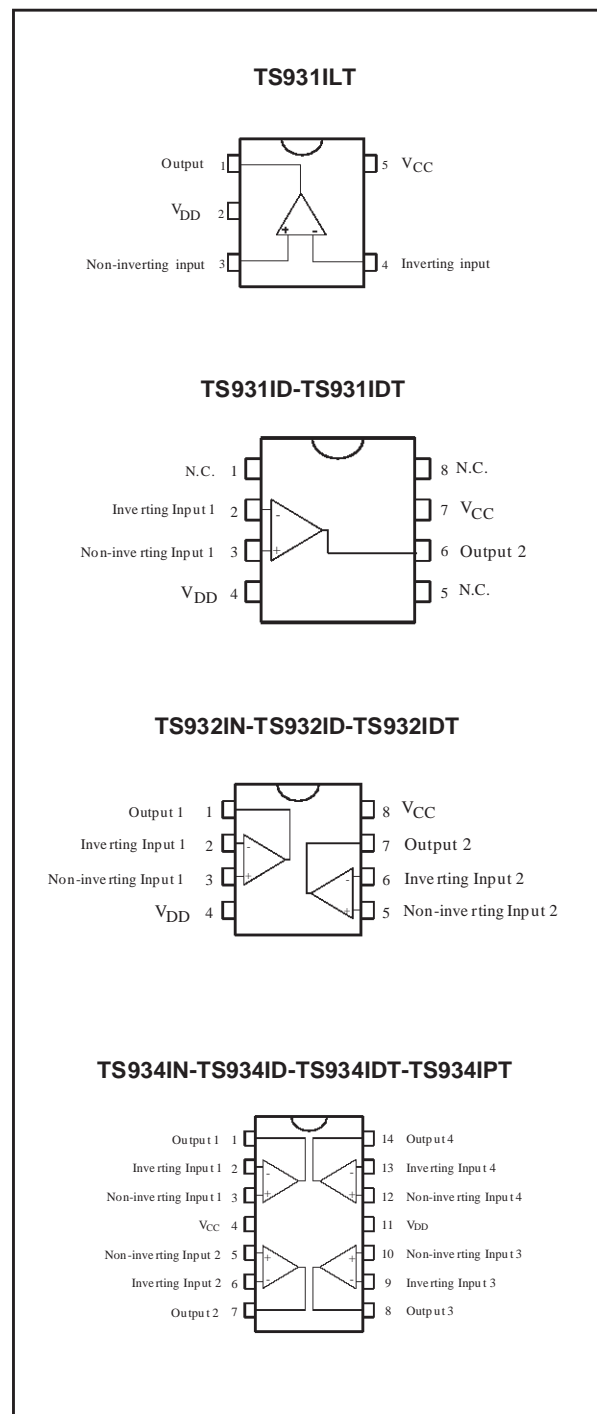
- Battery-powered systems
- Portable communication systems
- Alarm, smoke detectors
- Instrumentation & sensing
- PH Meter
- Digital scales

### ORDER CODE

| Part Number         | Temperature Range | Package |   |   |   | SOT23 Marking    |
|---------------------|-------------------|---------|---|---|---|------------------|
|                     |                   | N       | D | P | L |                  |
| TS931I<br>TS931A/BI | -40, +85°C        |         | • |   | • | K205<br>K206/207 |
| TS932I<br>TS932A/BI | -40, +85°C        | •       | • |   |   |                  |
| TS934I<br>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 <sup>1)</sup>                      | 12           | V    |
| $V_{id}$   | Differential Input Voltage <sup>2)</sup>          | $\pm 12$     | V    |
| $V_{in}$   | Input Voltage Range <sup>3)</sup>                 | -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 <sup>4)</sup> |              | °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<br>TS931/2/4<br>TS931/2/4A<br>TS931/2/4B   |      |            | 10<br>5<br>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<br>$0 \leq V_{icm} \leq V_{CC} - 1.7$   |      | 85         |              | dB                |
| SVR             | Supply Voltage Rejection Ratio <sup>2)</sup>  |      | 85         |              | dB                |
| $A_{vd}$        | Large Signal Voltage Gain<br>$V_O = 2V_{pp}$<br>$R_L = 1M\Omega$<br>$R_L = 100k\Omega$                                  |      | 120<br>106 |              | dB                |
| $V_{OH}$        | High Level Output Voltage<br>$V_{ID} = 100mV$<br>$R_L = 100k\Omega$   | 2.95 |            |              | V                 |
| $V_{OL}$        | Low Level Output Voltage<br>$V_{ID} = -100mV$<br>$R_L = 100k\Omega$   |      |            | 50           | mV                |
| $I_o$           | Output Source Current<br>$V_{ID} = 100mV$ , $V_O = V_{DD}$<br>Output Sink Current<br>$V_{ID} = -100mV$ , $V_O = V_{CC}$ |      | 1.5<br>1.5 |              | mA                |
| $I_{CC}$        | Supply Current (per amplifier)<br>$A_{VCL} = 1$ , no load   |      | 20         | 31           | $\mu A$           |
| GBP             | Gain Bandwidth Product<br>$R_L = 100k\Omega$ , $C_L = 50pF$   |      | 100        |              | kHz               |
| SR              | Slew Rate<br>$R_L = 100k\Omega$ , $C_L = 50pF$  |      | 50         |              | V/ms              |
| $\phi_m$        | Phase Margin<br>$C_L = 50pF$  |      | 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**

$V_{CC} = +5V$ ,  $V_{ee} = 0V$ ,

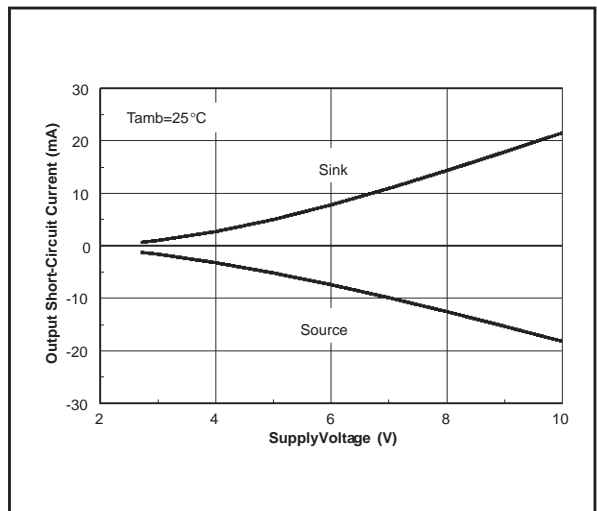
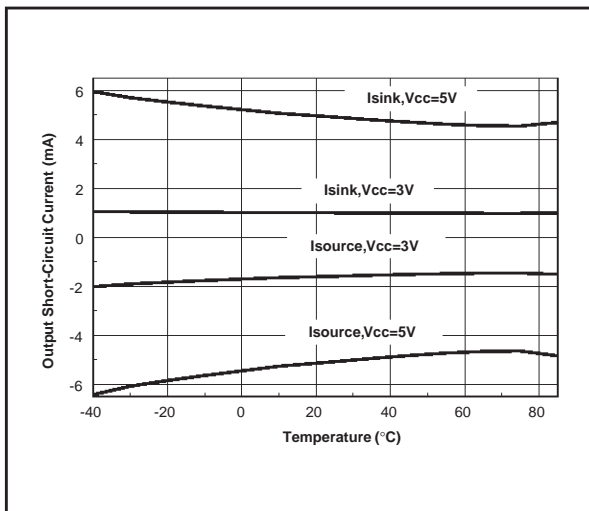
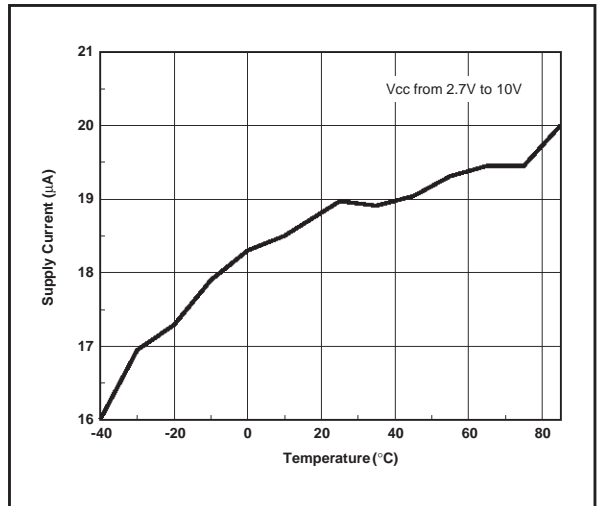
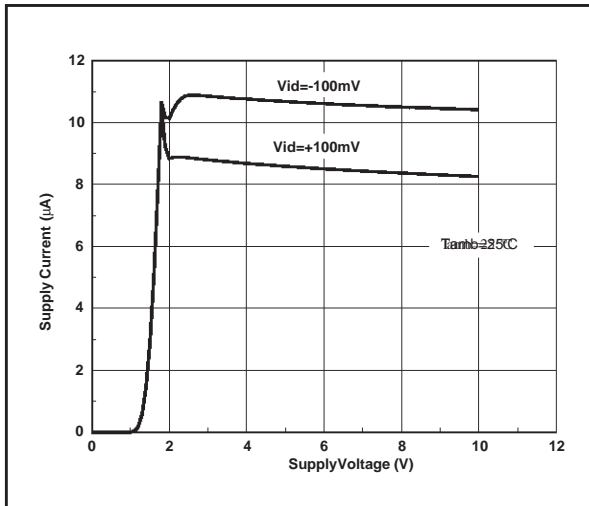
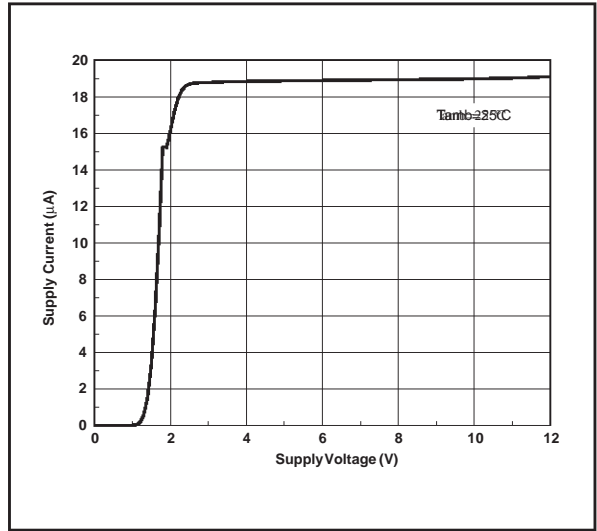
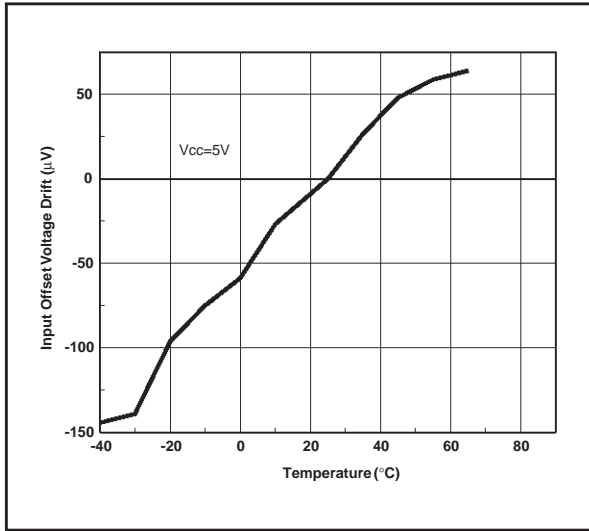
$T_{amb} = 25^{\circ}C$  (unless otherwise specified)

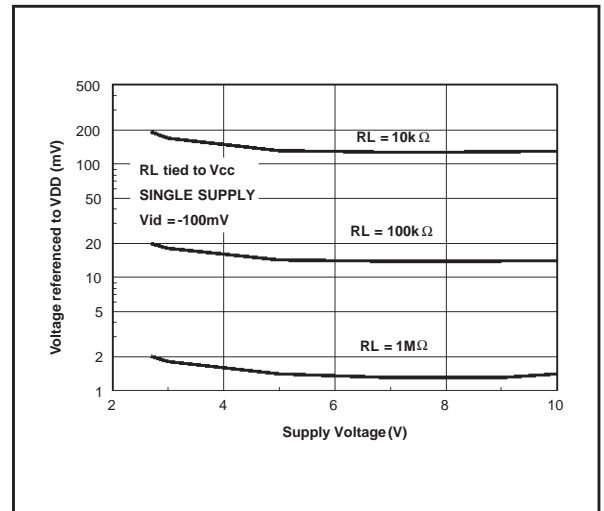
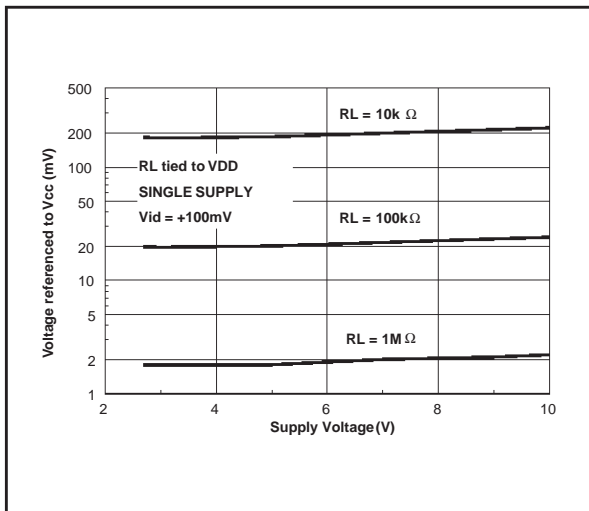
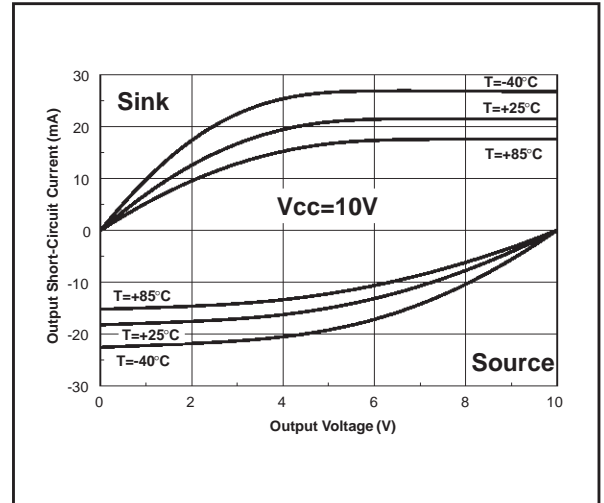
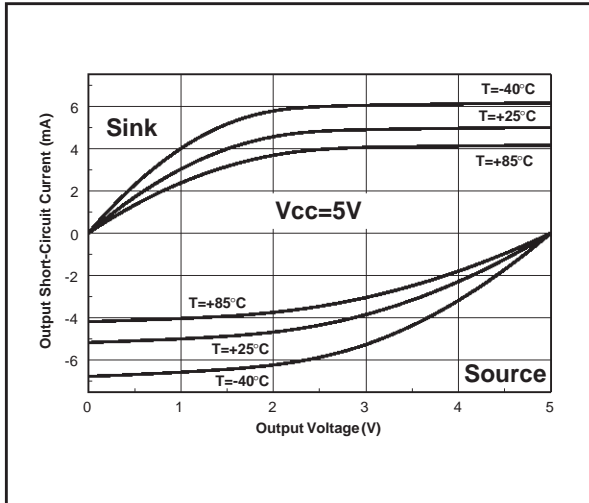
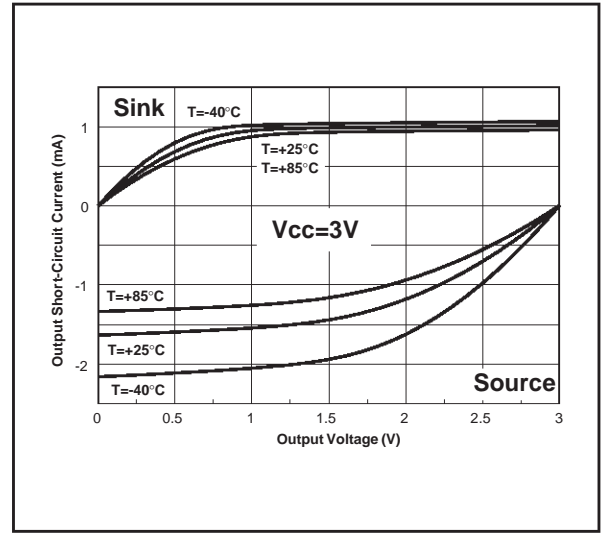
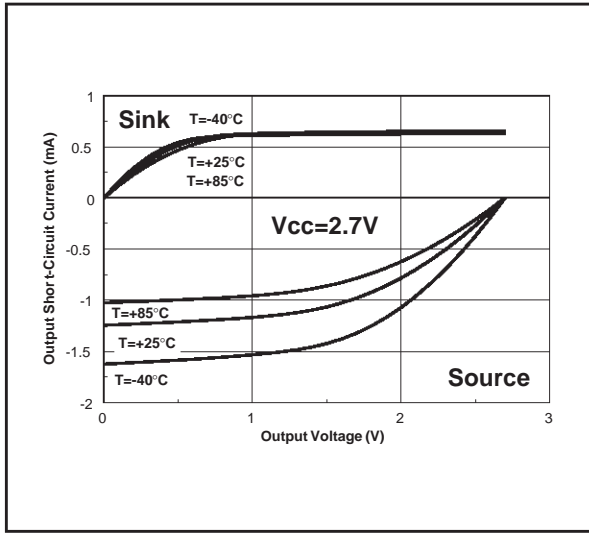
| Symbol          | Parameter   | Min. | Typ.       | Max.         | Unit              |
|-----------------|---|------|------------|--------------|-------------------|
| $V_{io}$        | Input Offset Voltage<br>TS931/2/4<br>TS931/2/4A<br>TS931/2/4B   |      |            | 10<br>5<br>2 | mV         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

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

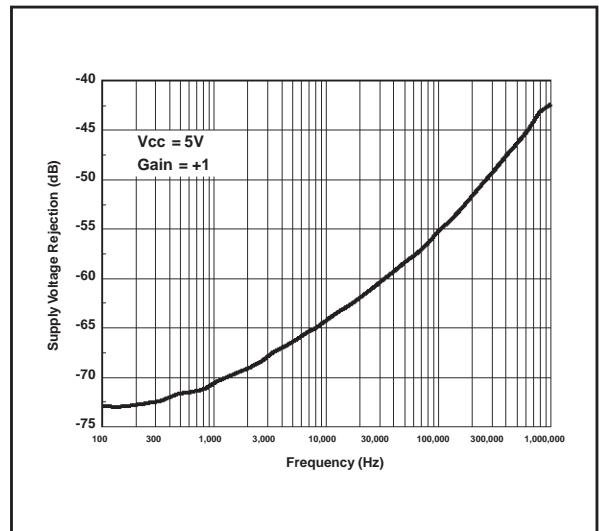
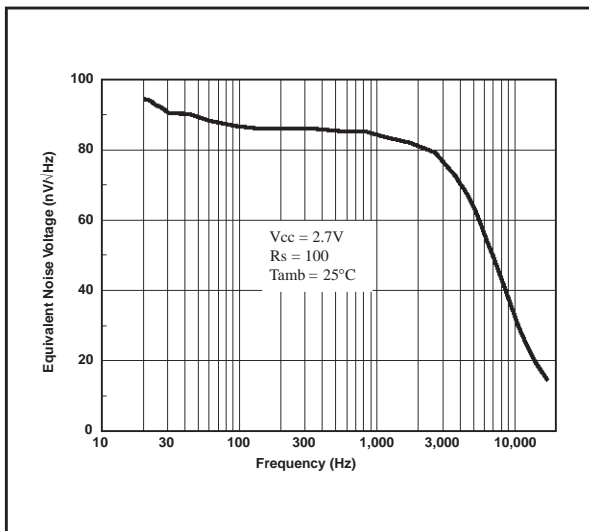
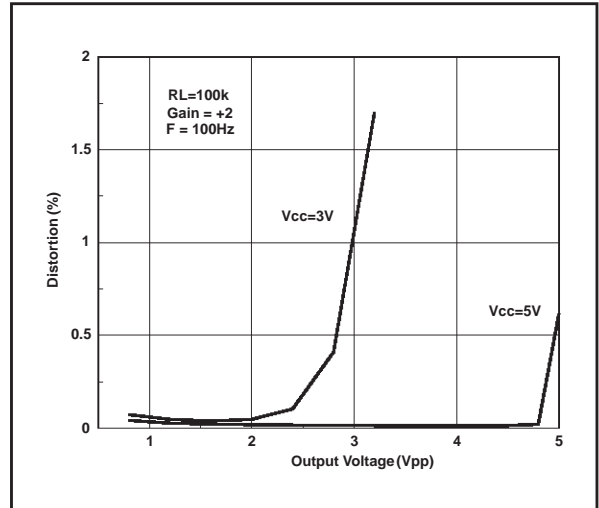
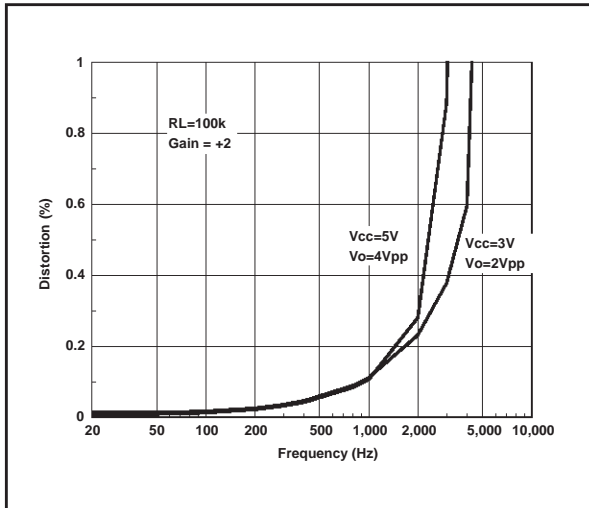
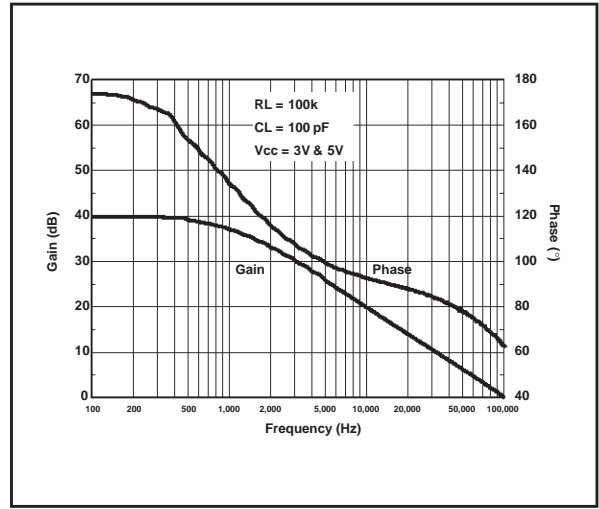
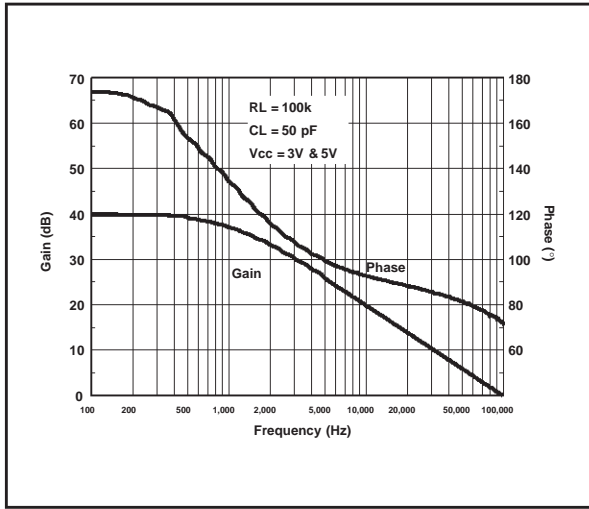
2.  $V_{CC}$  has a 0.2V variation.

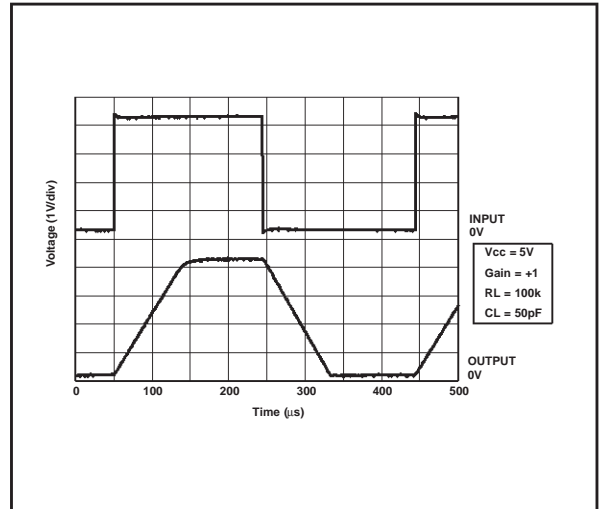
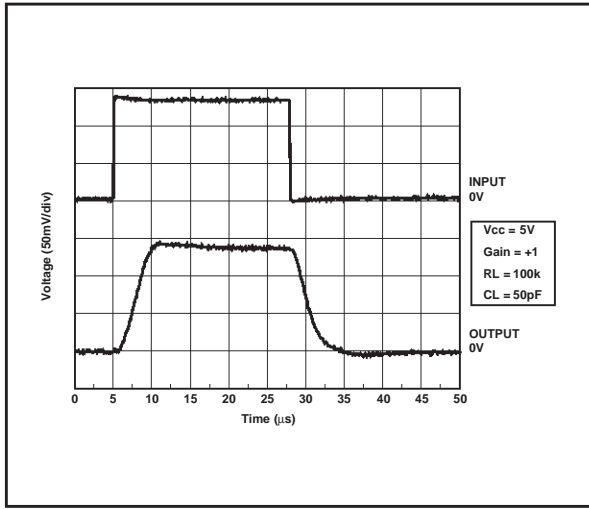
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TS931-TS932-TS934

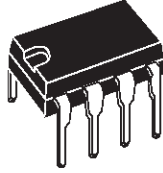




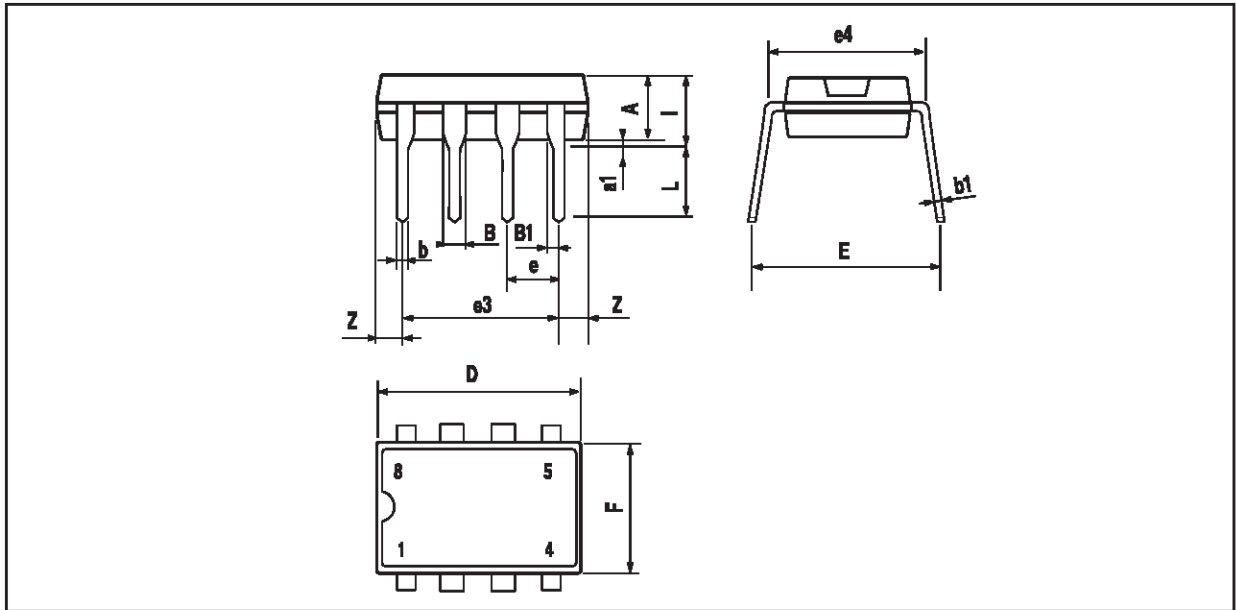


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TS932IN

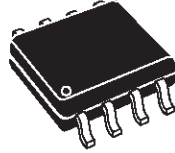


**PACKAGE MECHANICAL DATA**  
8 PINS - PLASTIC PACKAGE

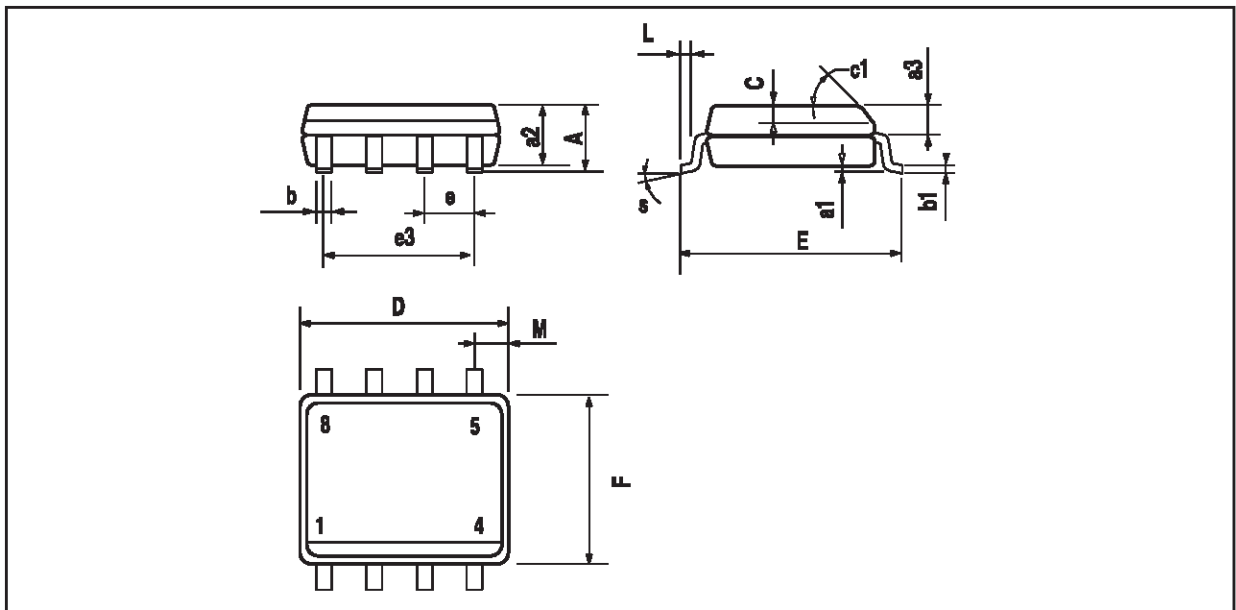


| Dim. | Millimeters |      |       | Inches |       |       |
|------|-------------|------|-------|--------|-------|-------|
|      | Min.        | Typ. | Max.  | Min.   | Typ.  | Max.  |
| A    |             | 3.32 |       |        | 0.131 |       |
| a1   | 0.51        |      |       | 0.020  |       |       |
| 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



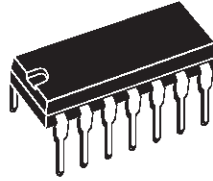
**PACKAGE MECHANICAL DATA**  
8 PINS - PLASTIC MICROPACKAGE (SO)



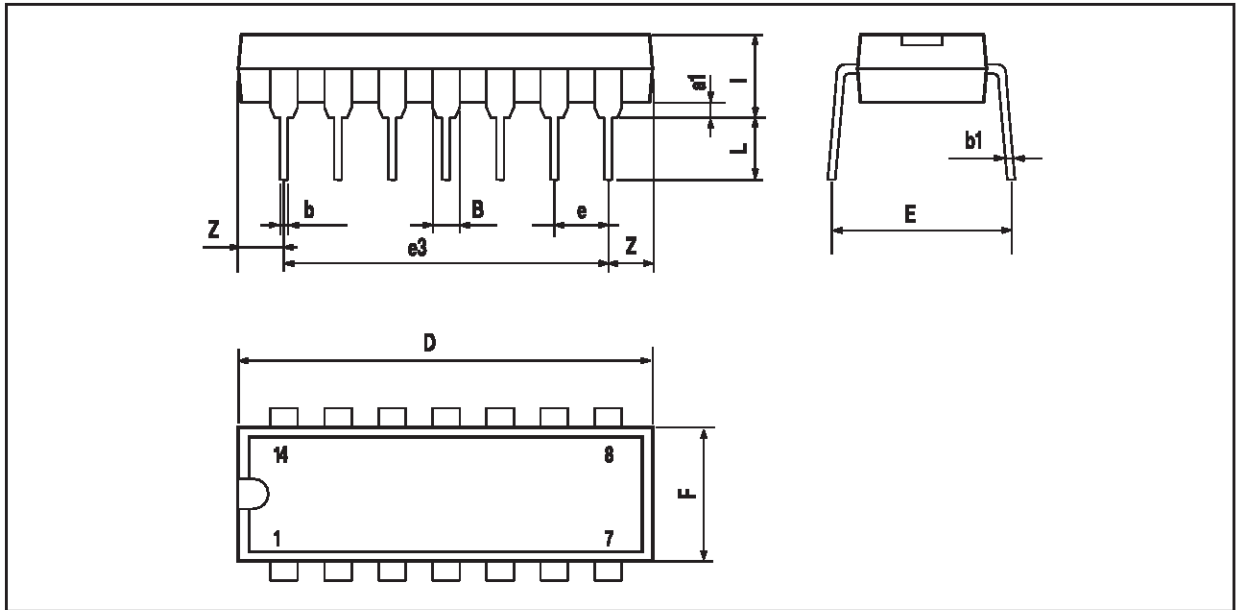
| Dim. | Millimeters |      |      | Inches |       |       |
|------|-------------|------|------|--------|-------|-------|
|      | Min.        | Typ. | Max. | Min.   | Typ.  | Max.  |
| A    |             |      | 1.75 |        |       | 0.069 |
| a1   | 0.1         |      | 0.25 | 0.004  |       | 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

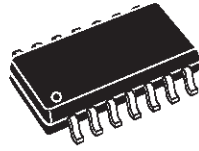


PACKAGE MECHANICAL DATA  
14 PINS - PLASTIC PACKAGE

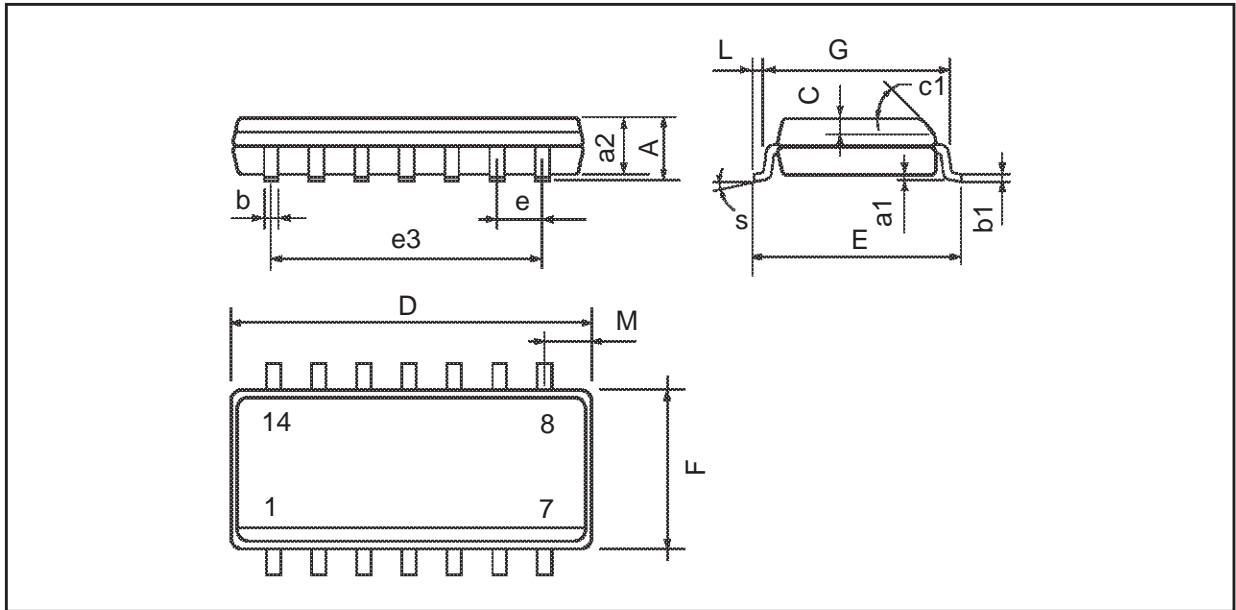


| Dim. | Millimeters |       |      | Inches |       |       |
|------|-------------|-------|------|--------|-------|-------|
|      | Min.        | Typ.  | Max. | Min.   | Typ.  | Max.  |
| a1   | 0.51        |       |      | 0.020  |       |       |
| B    | 1.39        |       | 1.65 | 0.055  |       | 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)

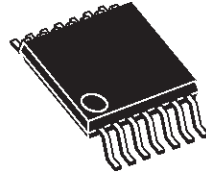


| Dim.  | Millimeters |      |      | Inches |       |       |
|-------|-------------|------|------|--------|-------|-------|
|       | Min.        | Typ. | Max. | Min.   | Typ.  | Max.  |
| A     |             |      | 1.75 |        |       | 0.069 |
| a1    | 0.1         |      | 0.2  | 0.004  |       | 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.

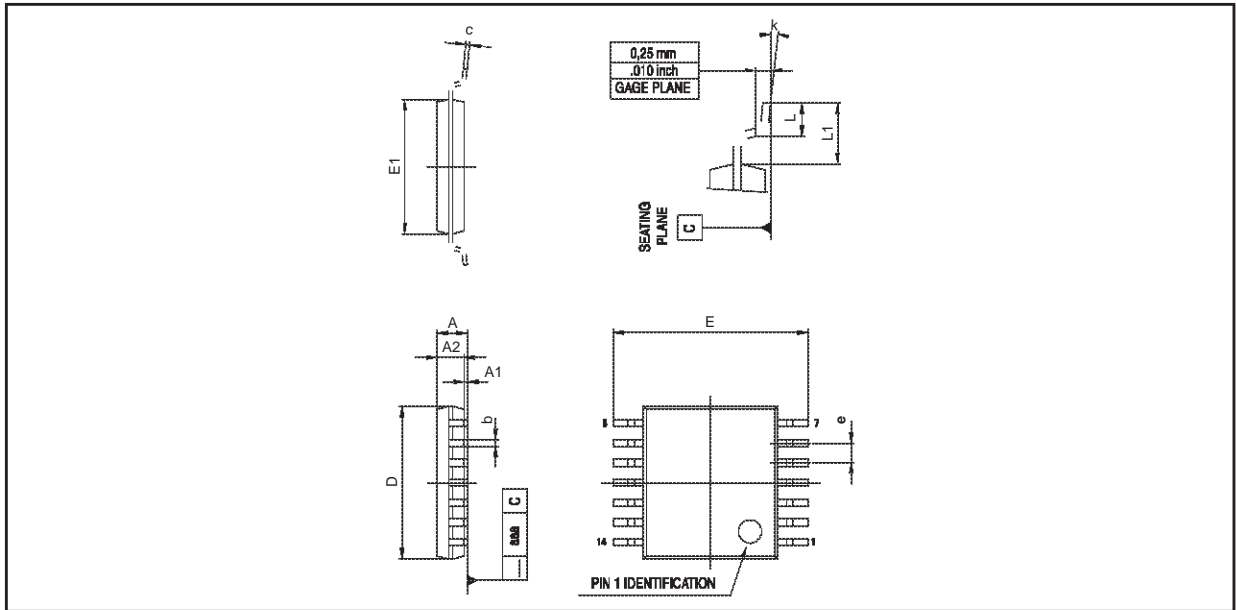
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**TS934IPT**



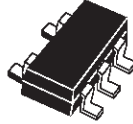
**PACKAGE MECHANICAL DATA**

14 PINS - THIN SHRINK SMALL OUTLINE PACKAGE

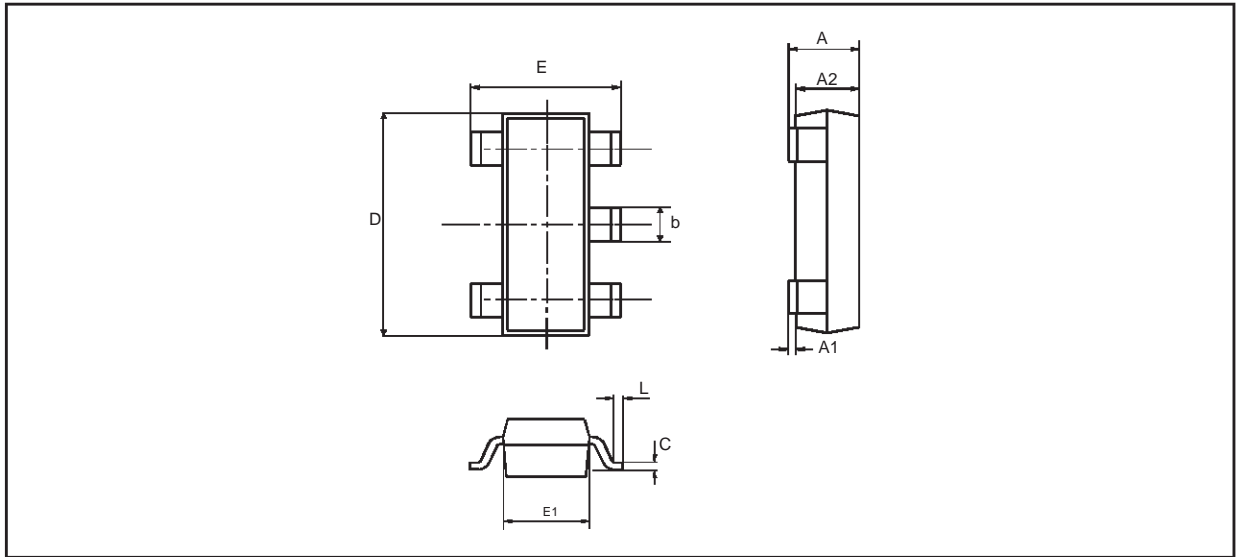


| Dim. | Millimeters |      |      | Inches |        |       |
|------|-------------|------|------|--------|--------|-------|
|      | Min.        | Typ. | Max. | Min.   | Typ.   | Max.  |
| A    |             |      | 1.20 |        |        | 0.05  |
| A1   | 0.05        |      | 0.15 | 0.01   |        | 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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