

## Output rail-to-rail micropower operational amplifiers

### Features

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

### Applications

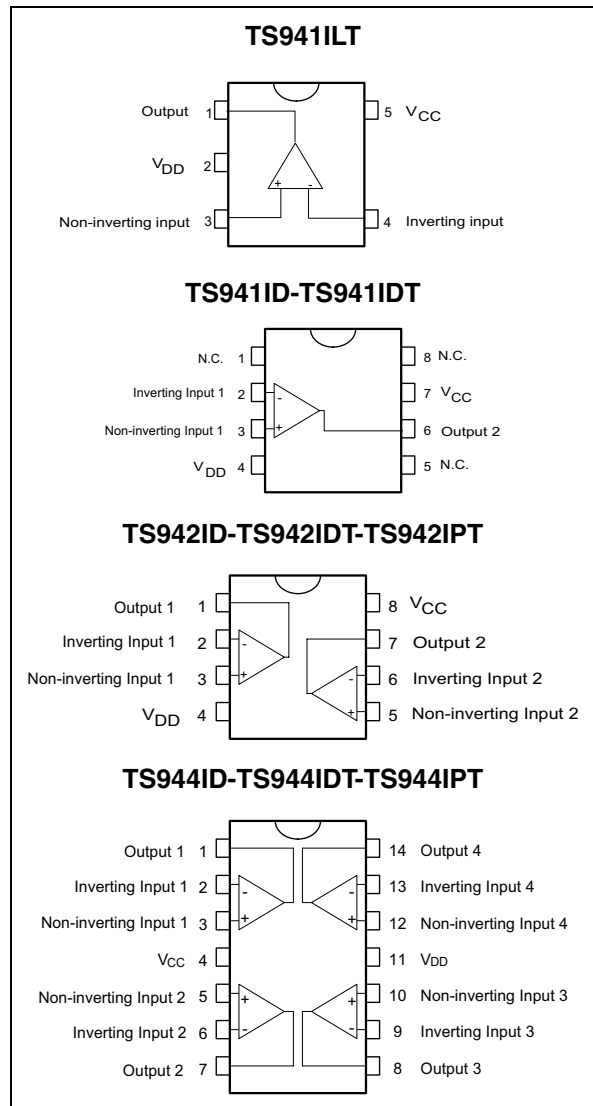
- Battery-powered systems (alarm)
- Portable communication systems (paggers)
- Smoke/gas/fire detectors
- Instrumentation and sensing
- PH meter

### Description

The TS94x (single, dual and quad) series are operational amplifiers characterized for 2.5 V to 10 V operation over a  $-40^{\circ}$  C to  $+85^{\circ}$  C temperature range.

They exhibit excellent consumption -1.2  $\mu$ A, while featuring 10 kHz gain bandwidth product, 1.5 mA output capability and output rail-to-rail operation - 2.85 V typical at 3 V with  $R_L=10$  k $\Omega$

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 - 1 pA typical input bias current and constant supply current over supply voltage enhance the devices' performance near the end of the battery charge or battery life.



**Table 1. Device summary**

| Reference | Selection on offset voltage |
|-----------|-----------------------------|
| TS94x     | TS941, TS942, TS944         |
| TS94xA    | TS941A, TS942A, TS944A      |
| TS94xB    | TS941B, TS942B, TS944B      |

# 1 Absolute maximum ratings and operating conditions

**Table 2. Absolute maximum ratings**

| Symbol     | Parameter   | Value                        | Unit |
|------------|---|------------------------------|------|
| $V_{CC}$   | Supply voltage <sup>(1)</sup>                         | 12                           | V    |
| $V_{id}$   | Differential input voltage <sup>(2)</sup>             | $\pm V_{CC}$                 | V    |
| $V_{in}$   | Input voltage range <sup>(3)</sup>                    | $V_{DD}-0.3$ to $V_{CC}+0.3$ | V    |
| $T_{stg}$  | Storage temperature range                             | -65 to +150                  | °C   |
| $T_j$      | Maximum junction temperature                          | 150                          | °C   |
| $R_{thja}$ | Thermal resistance junction to ambient <sup>(4)</sup> |                              |      |
|            | SOT23-5   | 250                          | °C/W |
|            | SO-8  | 125                          |      |
|            | SO-14   | 103                          |      |
|            | TSSOP8  | 120                          |      |
| TSSOP14    | 100   |                              |      |
| $R_{thjc}$ | Thermal resistance junction to case <sup>(4)</sup>    |                              |      |
|            | SOT23-5   | 81                           | °C/W |
|            | SO-8  | 40                           |      |
|            | SO-14   | 31                           |      |
|            | TSSOP8  | 37                           |      |
| TSSOP14    | 32  |                              |      |
| ESD        | HBM: human body model <sup>(5)</sup>                  | 2                            | kV   |
|            | MM: machine model <sup>(6)</sup> (TS941, TS942)       | 200                          | V    |
|            | CDM: charged device model <sup>(7)</sup>              |                              |      |
|            | TS941 - TS944IDT                                      | 1.5                          | kV   |
|            | TS942 - TS944IPT                                      | 1                            |      |
|            | Latch-up immunity                                     | 200                          | mA   |
|            | Lead temperature (soldering, 10sec)                   | 250                          | °C   |

1. All voltage values, except differential voltage are with respect to network terminal.
2. Differential voltages are the non-inverting input terminal with respect to the inverting input terminal.
3. The magnitude of input and output voltages must never exceed  $V_{CC} + 0.3$  V.
4. Short-circuits can cause excessive heating and destructive dissipation.  $R_{th}$  are typical values.
5. Human body model: a 100 pF capacitor is charged to the specified voltage, then discharged through a 1.5 k $\Omega$  resistor between two pins of the device. This is done for all couples of connected pin combinations while the other pins are floating.
6. Machine model: a 200 pF capacitor is charged to the specified voltage, then discharged directly between two pins of the device with no external series resistor (internal resistor < 5  $\Omega$ ). This is done for all couples of connected pin combinations while the other pins are floating.
7. Charged device model: all pins and the package are charged together to the specified voltage and then discharged directly to the ground through only one pin. This is done for all pins.

**Table 3. Operating conditions**

| Symbol     | Parameter                            | Value                            | Unit |
|------------|--------------------------------------|----------------------------------|------|
| $V_{CC}$   | Supply voltage                       | 2.5 to 10                        | V    |
| $V_{icm}$  | 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 4.**  $V_{CC} = +2.5\text{ V}$ ,  $V_{DD} = 0\text{ V}$ ,  $R_L$  connected to  $V_{CC}/2$ ,  $T_{amb} = 25^\circ\text{ C}$   
(unless otherwise specified)

| Symbol          | Parameter   | Min.        | Typ.        | Max.         | Unit                         |
|-----------------|---|-------------|-------------|--------------|------------------------------|
| $V_{io}$        | Input offset voltage<br>TS941/2/4<br>TS941/2/4A<br>TS941/2/4B   |             |             | 10<br>5<br>2 | mV                           |
| $\Delta V_{io}$ | Input offset voltage drift  |             | 7           |              | $\mu\text{V}/^\circ\text{C}$ |
| $I_{io}$        | 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   | 60          | 85          |              | dB                           |
| SVR             | Supply voltage rejection ratio  | 50          | 78          |              | dB                           |
| $A_{vd}$        | Large signal voltage gain<br>$V_O = 2 V_{pp}$ , $R_L = 1\text{ M}\Omega$  |             | 100         |              | dB                           |
| $V_{OH}$        | High level output voltage<br>$V_{ID} = 100\text{ mV}$ , $R_L = 1\text{ M}\Omega$<br>$R_L = 10\text{ k}\Omega$                           | 2.45<br>2.3 | 2.49<br>2.4 |              | V                            |
| $V_{OL}$        | Low level output voltage<br>$V_{ID} = -100\text{ mV}$ , $R_L = 1\text{ M}\Omega$<br>$R_L = 10\text{ k}\Omega$                           |             | 1<br>100    | 5<br>200     | mV                           |
| $I_o$           | Output source current<br>$V_{ID} = 100\text{ mV}$ , $V_O = V_{DD}$<br>Output sink current<br>$V_{ID} = -100\text{ mV}$ , $V_O = V_{CC}$ | 350<br>280  | 650<br>500  |              | $\mu\text{A}$                |
| $I_{CC}$        | Supply current (per amplifier), $A_{VCL} = 1$ , no load   |             | 1.2         | 1.8          | $\mu\text{A}$                |
| GBP             | Gain bandwidth product, $R_L = 1\text{ M}\Omega$ , $C_L = 50\text{ pF}$   |             | 10          |              | kHz                          |
| SR              | Slew rate, $R_L = 1\text{ M}\Omega$ , $C_L = 50\text{ pF}$  | 3           | 4.5         |              | V/ms                         |
| $\phi_m$        | Phase margin, $C_L = 50\text{ pF}$  |             | 65          |              | Degrees                      |

1. Maximum values include unavoidable inaccuracies of the industrial tests.

**Table 5.**  $V_{CC} = +3\text{ V}$ ,  $V_{DD} = 0\text{ V}$ ,  $R_L$  connected to  $V_{CC}/2$ ,  $T_{amb} = 25^\circ\text{ C}$   
(unless otherwise specified) <sup>(1)</sup>

| Symbol          | Parameter   | Min.       | Typ.         | Max.         | Unit                         |
|-----------------|---|------------|--------------|--------------|------------------------------|
| $V_{io}$        | Input offset voltage<br>TS941/2/4<br>TS941/2/4A<br>TS941/2/4B   |            |              | 10<br>5<br>2 | mV                           |
| $\Delta V_{io}$ | Input offset voltage drift  |            | 7            |              | $\mu\text{V}/^\circ\text{C}$ |
| $I_{io}$        | Input offset current <sup>(2)</sup>   |            | 1            | 100          | pA                           |
| $I_{ib}$        | Input bias current <sup>(2)</sup>   |            | 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<br>$V_O = 2 V_{pp}, R_L = 1\text{ M}\Omega$   |            | 100          |              | dB                           |
| $V_{OH}$        | High level output voltage<br>$V_{ID} = 100\text{ mV}, R_L = 1\text{ M}\Omega$<br>$R_L = 10\text{ k}\Omega$                        | 2.9<br>2.8 | 2.99<br>2.85 |              | V                            |
| $V_{OL}$        | Low level output voltage<br>$V_{ID} = -100\text{ mV}, R_L = 1\text{ M}\Omega$<br>$R_L = 10\text{ k}\Omega$                        |            | 1<br>100     | 5<br>200     | mV                           |
| $I_o$           | Output source current<br>$V_{ID} = 100\text{ mV}, V_O = V_{DD}$<br>Output sink current<br>$V_{ID} = -100\text{ mV}, V_O = V_{CC}$ | 680<br>650 | 1500<br>1300 |              | $\mu\text{A}$                |
| $I_{CC}$        | Supply current (per amplifier), $A_{VCL} = 1$ , no load   |            | 1.2          | 1.8          | $\mu\text{A}$                |
| GBP             | Gain bandwidth product, $R_L = 1\text{ M}\Omega, C_L = 50\text{ pF}$  |            | 10           |              | kHz                          |
| SR              | Slew rate, $R_L = 1\text{ M}\Omega, C_L = 50\text{ pF}$   | 3          | 4.5          |              | V/ms                         |
| $\phi_m$        | Phase margin, $C_L = 50\text{ pF}$  |            | 65           |              | Degrees                      |

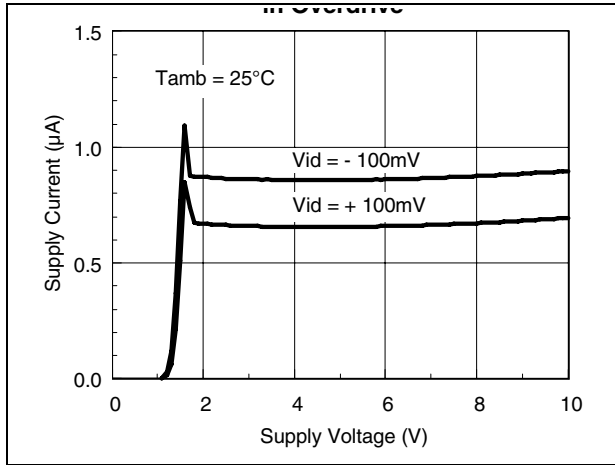
1. All electrical values are guaranteed with correlation measurements at 2.5 V and 5 V.
2. Maximum values include unavoidable inaccuracies of the industrial tests.

**Table 6.**  $V_{CC} = +5\text{ V}$ ,  $V_{DD} = 0\text{ V}$ ,  $R_L$  connected to  $V_{CC}/2$ ,  $T_{amb} = 25^\circ\text{ C}$   
(unless otherwise specified)

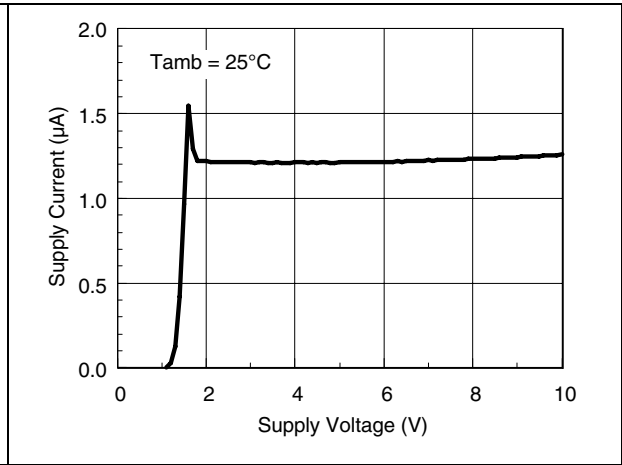
| Symbol          | Parameter   | Min.       | Typ.         | Max.         | Unit                         |
|-----------------|---|------------|--------------|--------------|------------------------------|
| $V_{io}$        | Input offset voltage<br>TS941/2/4<br>TS941/2/4A<br>TS941/2/4B   |            |              | 10<br>5<br>2 | mV                           |
| $\Delta V_{io}$ | Input offset voltage drift  |            | 7            |              | $\mu\text{V}/^\circ\text{C}$ |
| $I_{io}$        | 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   | 60         | 85           |              | dB                           |
| SVR             | Supply voltage rejection ratio  | 50         | 85           |              | dB                           |
| $A_{vd}$        | Large signal voltage gain<br>$V_O = 2 V_{pp}$ , $R_L = 1\text{ M}\Omega$  |            | 100          |              | dB                           |
| $V_{OH}$        | High level output voltage<br>$V_{ID} = 100\text{ mV}$ , $R_L = 1\text{ M}\Omega$<br>$R_L = 10\text{ k}\Omega$                           | 4.9<br>4.8 | 4.99<br>4.85 |              | V                            |
| $V_{OL}$        | Low level output voltage<br>$V_{ID} = -100\text{ mV}$ , $R_L = 1\text{ M}\Omega$<br>$R_L = 10\text{ k}\Omega$                           |            | 1<br>100     | 5<br>150     | mV                           |
| $I_o$           | Output source current<br>$V_{ID} = 100\text{ mV}$ , $V_O = V_{DD}$<br>Output sink current<br>$V_{ID} = -100\text{ mV}$ , $V_O = V_{CC}$ | 3<br>3.7   | 4.5<br>5     |              | mA                           |
| $I_{CC}$        | Supply current (per amplifier), $A_{VCL} = 1$ , no load   |            | 1.2          | 1.85         | $\mu\text{A}$                |
| GBP             | Gain bandwidth product, $R_L = 1\text{ M}\Omega$ , $C_L = 50\text{ pF}$   |            | 10           |              | kHz                          |
| SR              | Slew rate, $R_L = 1\text{ M}\Omega$ , $C_L = 50\text{ pF}$  | 3          | 4.5          |              | V/ms                         |
| $\phi_m$        | Phase margin, $C_L = 50\text{ pF}$  |            | 65           |              | Degrees                      |

1. Maximum values include unavoidable inaccuracies of the industrial tests.

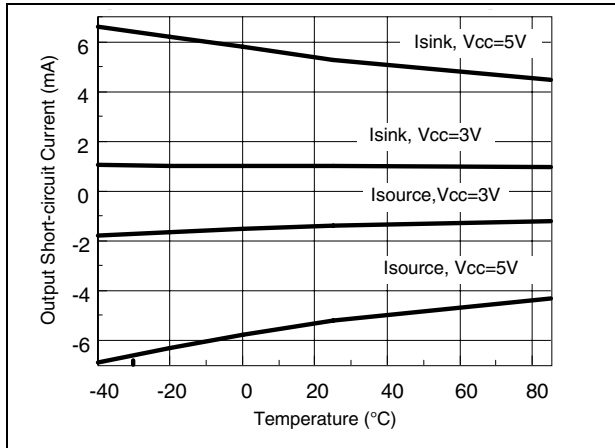
**Figure 1. Supply current per amplifier vs. supply voltage in overdrive**



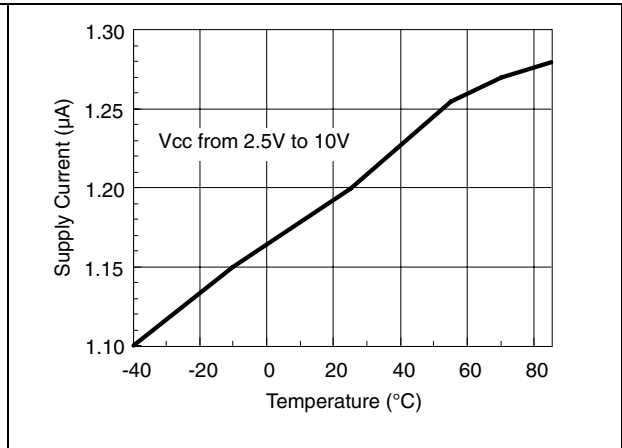
**Figure 2. Supply current per amplifier vs. supply voltage**



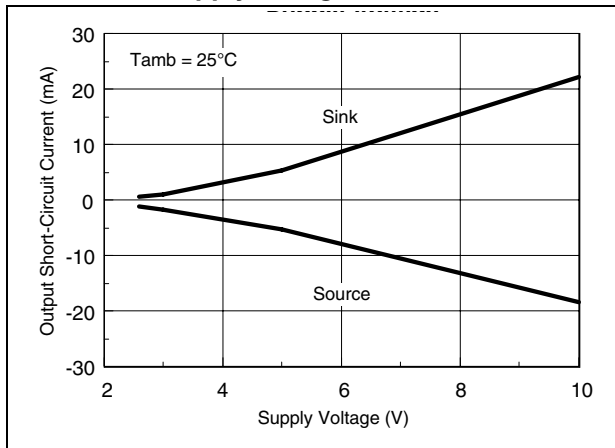
**Figure 3. Output short-circuit current vs. temperature**



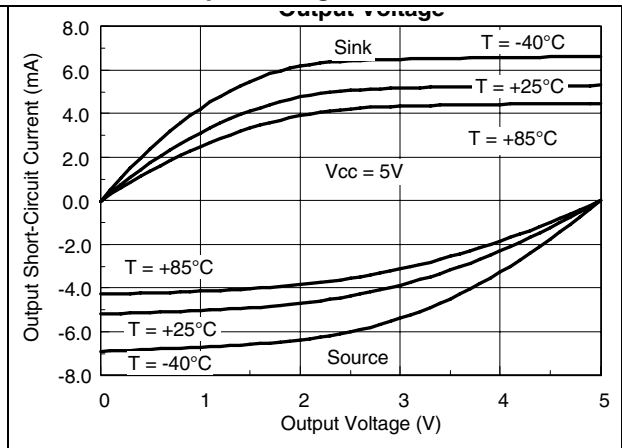
**Figure 4. Supply current per amplifier vs. temperature**



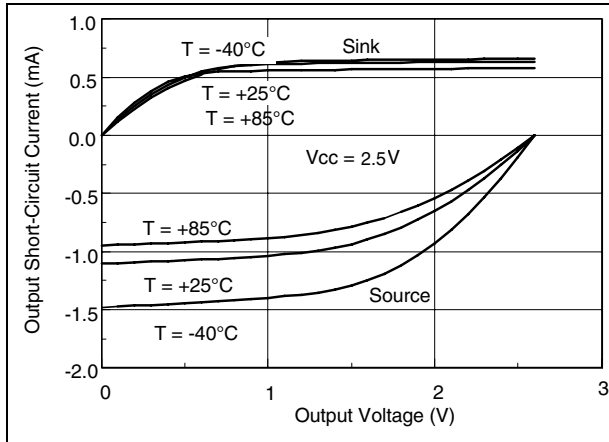
**Figure 5. Output short-circuit current vs. supply voltage**



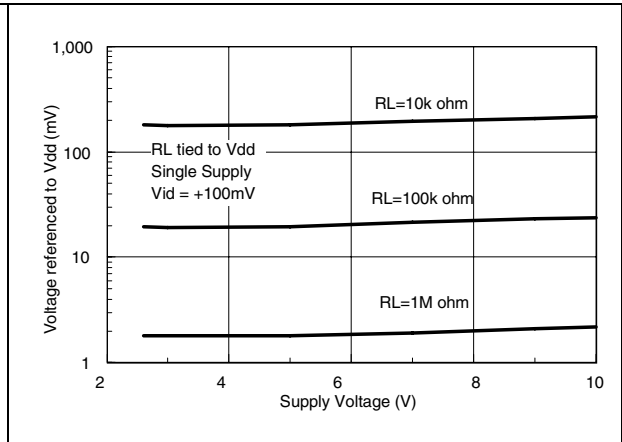
**Figure 6. Output short-circuit current vs. output voltage**



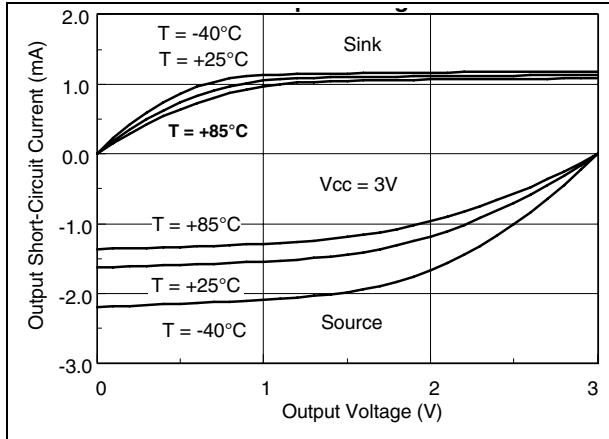
**Figure 7. Output short-circuit current vs. output voltage**



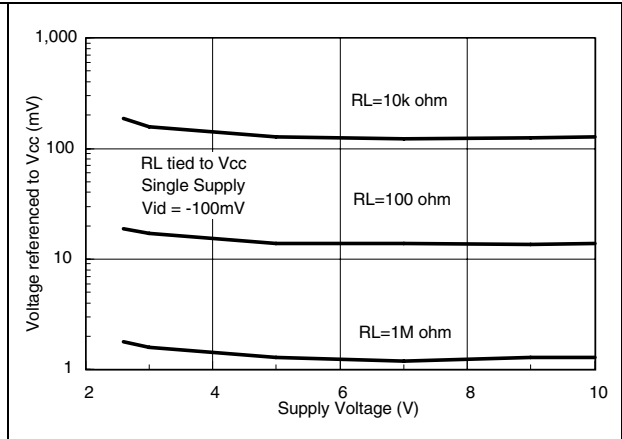
**Figure 8. High level output voltage vs. supply voltage**



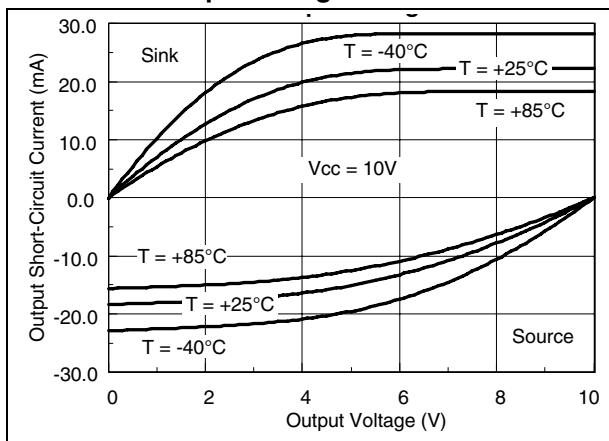
**Figure 9. Output short-circuit current vs. output voltage**



**Figure 10. Low level output voltage vs. supply voltage**



**Figure 11. Output short-circuit current vs. output voltage**



**Figure 12. Gain and phase vs. frequency**

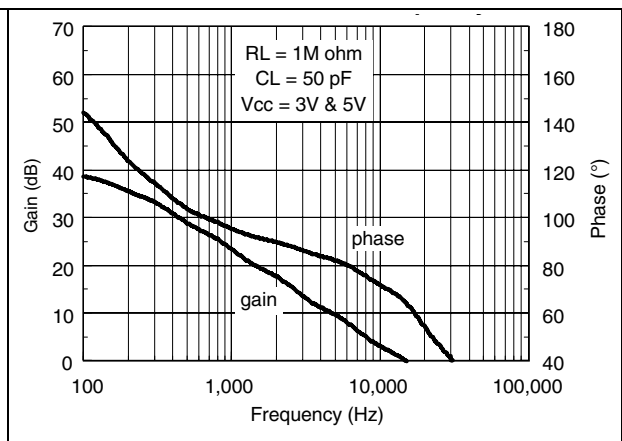




Figure 13. Small signal transient response

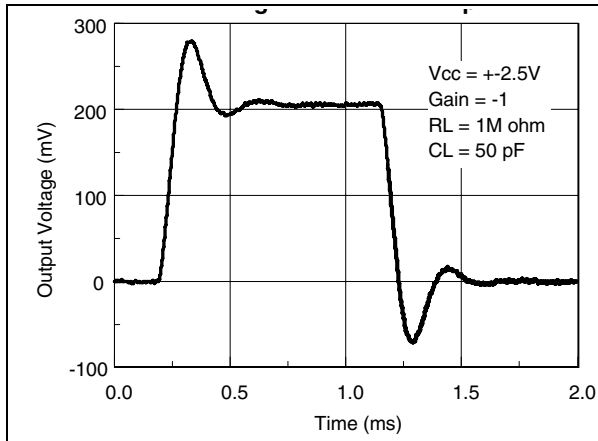


Figure 14. Gain and phase versus frequency

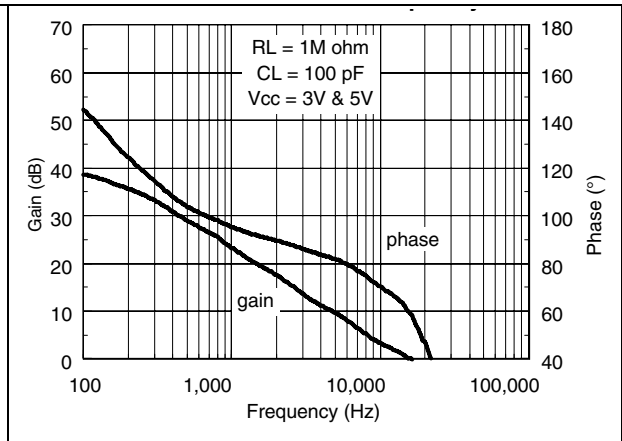


Figure 15. Slew rate positive and negative vs. temperature

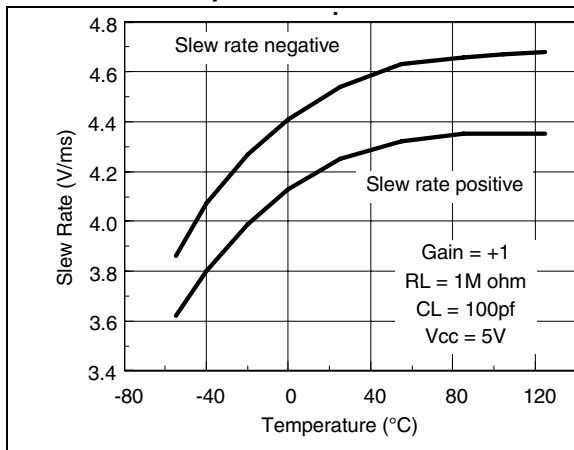
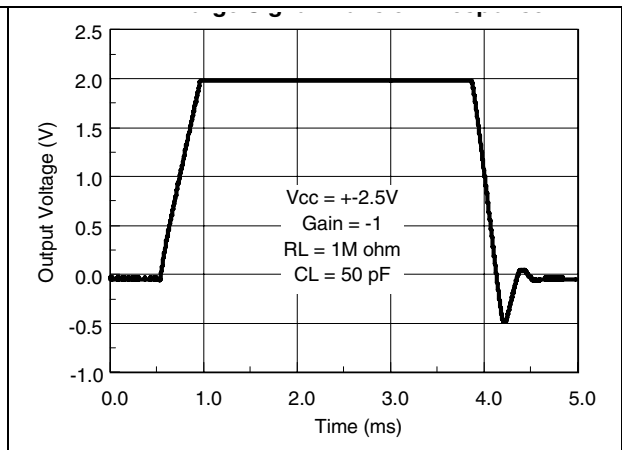


Figure 16. Large signal transient response



### 3 Package information

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK<sup>®</sup> packages, depending on their level of environmental compliance. ECOPACK<sup>®</sup> specifications, grade definitions and product status are available at: [www.st.com](http://www.st.com). ECOPACK<sup>®</sup> is an ST trademark.

### 3.1 SOT23-5 package information

Figure 17. SOT23-5 package mechanical drawing

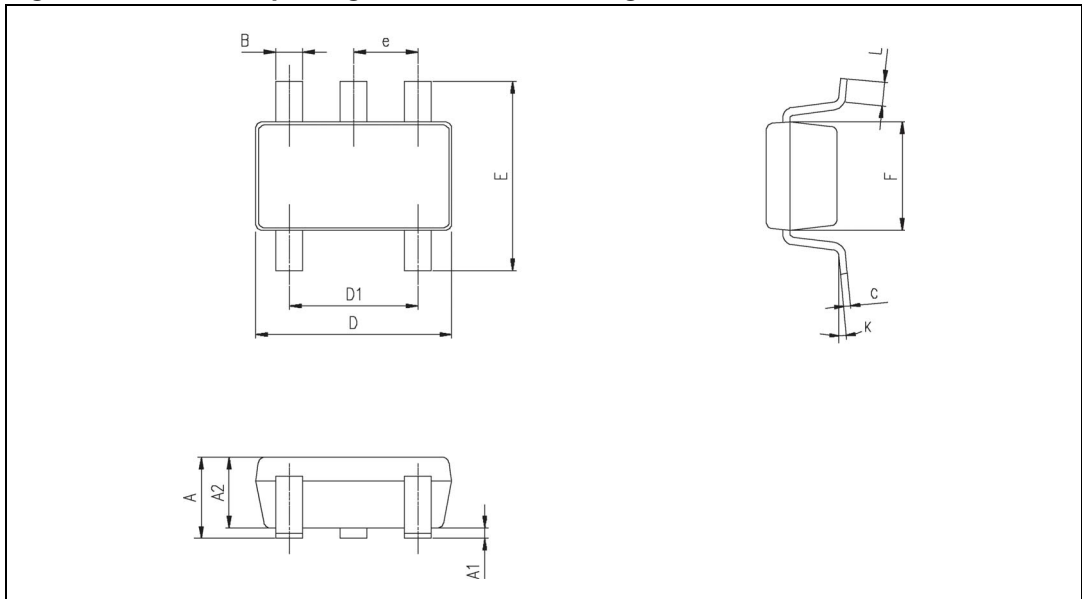


Table 7. SOT23-5 package mechanical data

| Ref. | Dimensions  |      |            |        |       |       |
|------|-------------|------|------------|--------|-------|-------|
|      | Millimeters |      |            | Inches |       |       |
|      | Min.        | Typ. | Max.       | Min.   | Typ.  | Max.  |
| A    | 0.90        | 1.20 | 1.45       | 0.035  | 0.047 | 0.057 |
| A1   |             |      | 0.15       |        |       | 0.006 |
| A2   | 0.90        | 1.05 | 1.30       | 0.035  | 0.041 | 0.051 |
| B    | 0.35        | 0.40 | 0.50       | 0.013  | 0.015 | 0.019 |
| C    | 0.09        | 0.15 | 0.20       | 0.003  | 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 | 0.118 |
| F    | 1.50        | 1.60 | 1.75       | 0.059  | 0.063 | 0.069 |
| L    | 0.10        | 0.35 | 0.60       | 0.004  | 0.013 | 0.023 |
| K    | 0 degrees   |      | 10 degrees |        |       |       |

### 3.2 SO-8 package information

Figure 18. SO-8 package mechanical drawing

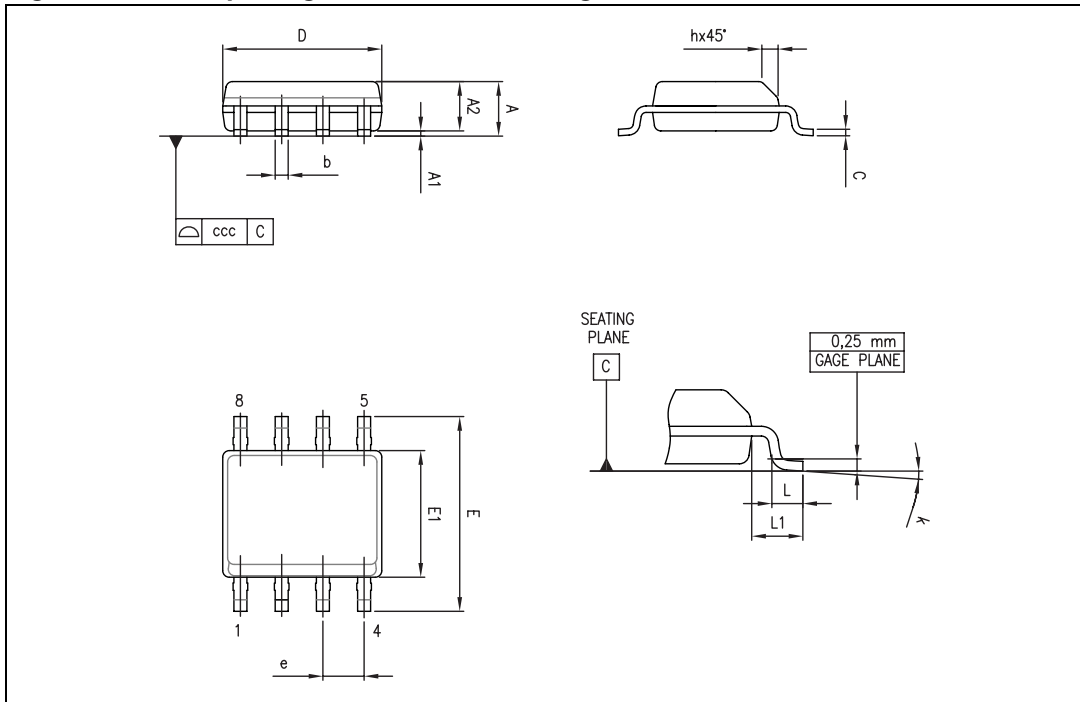


Table 8. SO-8 package mechanical data

| Ref. | Dimensions  |      |      |        |       |       |
|------|-------------|------|------|--------|-------|-------|
|      | Millimeters |      |      | Inches |       |       |
|      | Min.        | Typ. | Max. | Min.   | Typ.  | Max.  |
| A    |             |      | 1.75 |        |       | 0.069 |
| A1   | 0.10        |      | 0.25 | 0.004  |       | 0.010 |
| A2   | 1.25        |      |      | 0.049  |       |       |
| b    | 0.28        |      | 0.48 | 0.011  |       | 0.019 |
| c    | 0.17        |      | 0.23 | 0.007  |       | 0.010 |
| D    | 4.80        | 4.90 | 5.00 | 0.189  | 0.193 | 0.197 |
| E    | 5.80        | 6.00 | 6.20 | 0.228  | 0.236 | 0.244 |
| E1   | 3.80        | 3.90 | 4.00 | 0.150  | 0.154 | 0.157 |
| e    |             | 1.27 |      |        | 0.050 |       |
| h    | 0.25        |      | 0.50 | 0.010  |       | 0.020 |
| L    | 0.40        |      | 1.27 | 0.016  |       | 0.050 |
| L1   |             | 1.04 |      |        | 0.040 |       |
| k    | 0           |      | 8°   | 1°     |       | 8°    |
| ccc  |             |      | 0.10 |        |       | 0.004 |

### 3.3 TSSOP8 package information

Figure 19. TSSOP8 package mechanical drawing

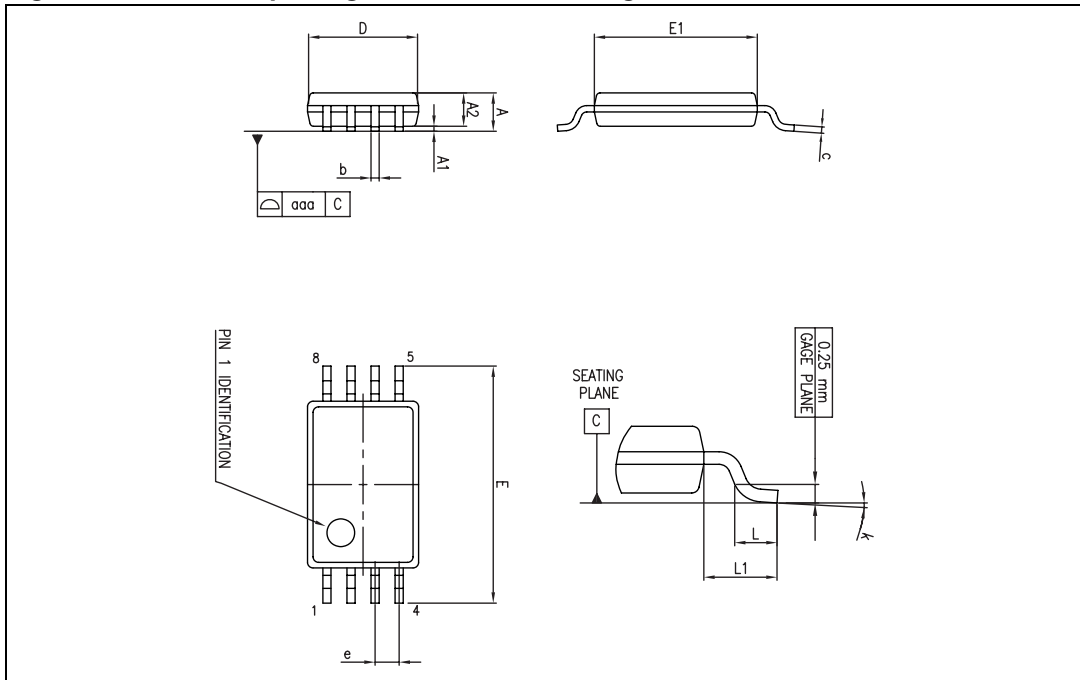


Table 9. TSSOP8 package mechanical data

| Ref. | Dimensions  |      |      |        |        |       |
|------|-------------|------|------|--------|--------|-------|
|      | Millimeters |      |      | Inches |        |       |
|      | Min.        | Typ. | Max. | Min.   | Typ.   | Max.  |
| A    |             |      | 1.20 |        |        | 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  |       |
| aaa  |             |      | 0.10 |        |        | 0.004 |

### 3.4 SO-14 package information

Figure 20. SO-14 package mechanical drawing

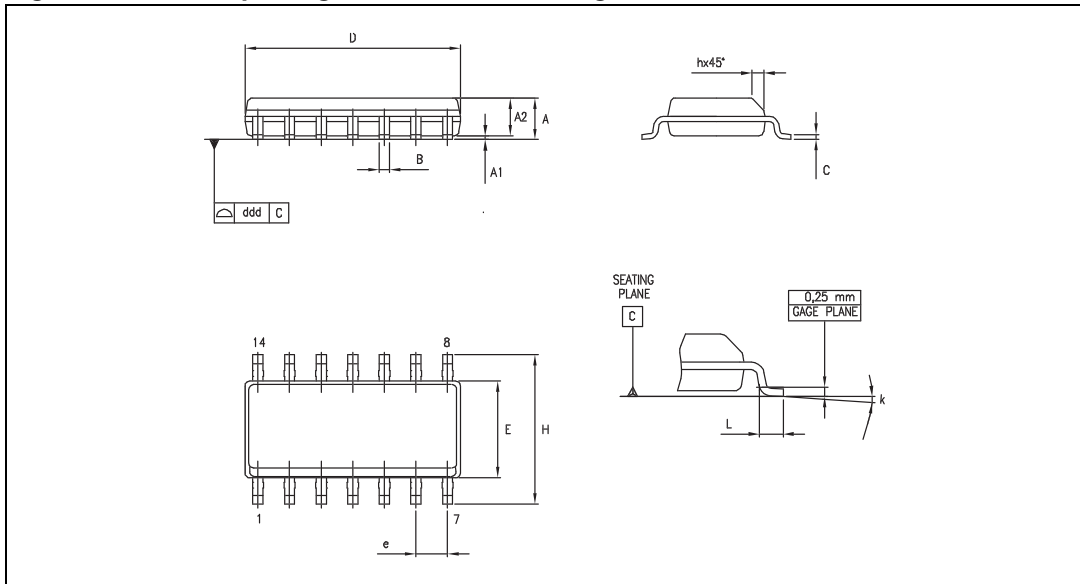


Table 10. SO-14 package mechanical data

| Dimensions |             |      |      |        |      |       |
|------------|-------------|------|------|--------|------|-------|
| Ref.       | Millimeters |      |      | Inches |      |       |
|            | Min.        | Typ. | Max. | Min.   | Typ. | Max.  |
| A          | 1.35        |      | 1.75 | 0.05   |      | 0.068 |
| A1         | 0.10        |      | 0.25 | 0.004  |      | 0.009 |
| A2         | 1.10        |      | 1.65 | 0.04   |      | 0.06  |
| B          | 0.33        |      | 0.51 | 0.01   |      | 0.02  |
| C          | 0.19        |      | 0.25 | 0.007  |      | 0.009 |
| D          | 8.55        |      | 8.75 | 0.33   |      | 0.34  |
| E          | 3.80        |      | 4.0  | 0.15   |      | 0.15  |
| e          |             | 1.27 |      |        | 0.05 |       |
| H          | 5.80        |      | 6.20 | 0.22   |      | 0.24  |
| h          | 0.25        |      | 0.50 | 0.009  |      | 0.02  |
| L          | 0.40        |      | 1.27 | 0.015  |      | 0.05  |
| k          | 8° (max.)   |      |      |        |      |       |
| ddd        |             |      | 0.10 |        |      | 0.004 |

### 3.5 TSSOP14 package information

Figure 21. TSSOP14 package mechanical drawing

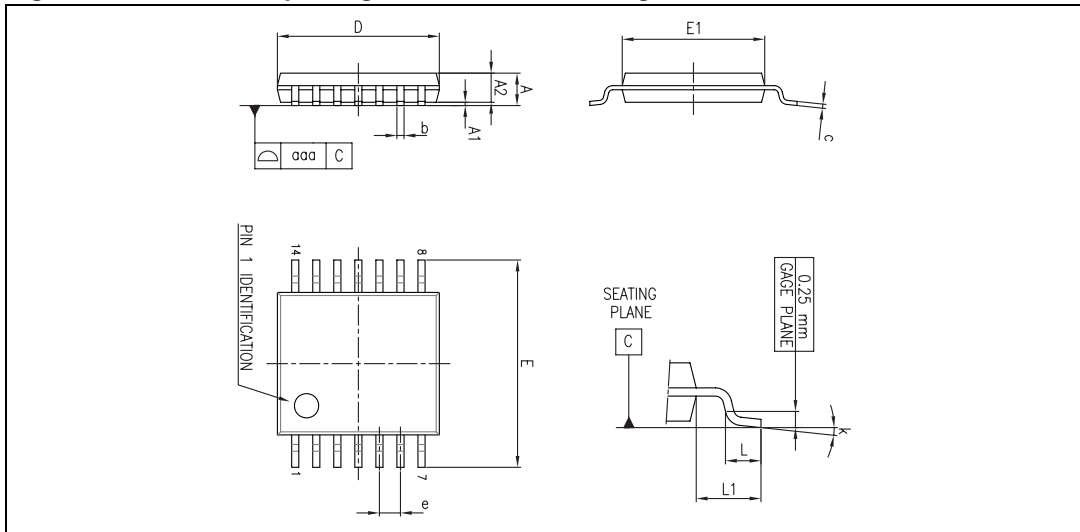


Table 11. TSSOP14 package mechanical data

| Ref. | Dimensions  |      |      |        |        |        |
|------|-------------|------|------|--------|--------|--------|
|      | Millimeters |      |      | Inches |        |        |
|      | Min.        | Typ. | Max. | Min.   | Typ.   | Max.   |
| A    |             |      | 1.20 |        |        | 0.047  |
| A1   | 0.05        |      | 0.15 | 0.002  | 0.004  | 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  |        | 0.0089 |
| D    | 4.90        | 5.00 | 5.10 | 0.193  | 0.197  | 0.201  |
| E    | 6.20        | 6.40 | 6.60 | 0.244  | 0.252  | 0.260  |
| E1   | 4.30        | 4.40 | 4.50 | 0.169  | 0.173  | 0.176  |
| e    |             | 0.65 |      |        | 0.0256 |        |
| L    | 0.45        | 0.60 | 0.75 | 0.018  | 0.024  | 0.030  |
| L1   |             | 1.00 |      |        | 0.039  |        |
| k    | 0°          |      | 8°   | 0°     |        | 8°     |
| aaa  |             |      | 0.10 |        |        | 0.004  |

## 4 Ordering information

**Table 12. Order codes**

| Order code            | Temperature range | Package  | Packaging              | Marking               |
|-----------------------|-------------------|----------|------------------------|-----------------------|
| TS941ID<br>TS941IDT   | -40°C to +85°C    | SO-8     | Tube or<br>Tape & reel | TS941ID<br>TS941IDT   |
| TS941AID<br>TS941AIDT |                   |          |                        | TS941AID              |
| TS941BID<br>TS941BIDT |                   |          |                        | TS941BID              |
| TS941ILT              |                   | SOT23-5L | Tape & reel            | K201                  |
| TS941AILT             |                   |          |                        | K202                  |
| TS941BILT             |                   |          |                        | K203                  |
| TS942ID<br>TS942IDT   |                   | SO-8     | Tube or<br>Tape & reel | TS942ID<br>TS942IDT   |
| TS942AID<br>TS942AIDT |                   |          |                        | TS942AID              |
| TS942BID<br>TS942BIDT |                   |          |                        | TS942BID              |
| TS942IPT              |                   | TSSOP8   | Tape & reel            | TS942                 |
| TS942AIPT             |                   |          |                        | 942AI                 |
| TS942BIPT             |                   |          |                        | 942BI                 |
| TS944ID<br>TS944IDT   |                   | SO-14    | Tube or<br>Tape & reel | TS944ID<br>TS944IDT   |
| TS944AID<br>TS944AIDT |                   |          |                        | TS944AID<br>TS944AIDT |
| TS944BID<br>TS944BIDT |                   |          |                        | TS944BID<br>TS944BIDT |
| TS944IPT              |                   | TSSOP14  | Tape & reel            | TS944IPT              |
| TS944AIPT             |                   |          |                        | TS944AI               |
| TS944BIPT             |                   |          |                        | TS944BI               |



## 5 Revision history

**Table 13. Document revision history**

| Date        | Revision | Changes   |
|-------------|----------|---|
| 01-Dec-2001 | 1        | Initial release.  |
| 01-Dec-2004 | 2        | Modifications on AMR table (explanation of $V_{id}$ and $V_{in}$ limits).   |
| 13-Mar-2008 | 3        | CDM values added for TS944 in SO and TSSOP packages.<br>Document reformatted.   |
| 09-Apr-2008 | 4        | Corrected error in power consumption on cover page (1.2 $\mu$ A, not 1.2mA).  |
| 05-Mar-2009 | 5        | Removed DIP package information and order codes in <a href="#">Chapter 3</a> and <a href="#">Chapter 4</a> .<br>Updated all other package mechanical drawings and data in <a href="#">Chapter 3</a> . |
| 06-Oct-2009 | 6        | Added root part numbers (TS94xA, TS94xB) and <a href="#">Table 1: Device summary</a> on cover page.   |