

## 1.225V micropower shunt voltage reference

### Features

- 1.225V typical output voltage
- Ultra low operating current: 65 $\mu$ A maximum at 25°C
- High precision @ 25°C
  - +/- 2%
  - +/- 1%
  - +/- 0.5%
- High stability when used with capacitive loads
- Industrial temperature range: -40°C to +85°C
- 150ppm/°C maximum temperature coefficient

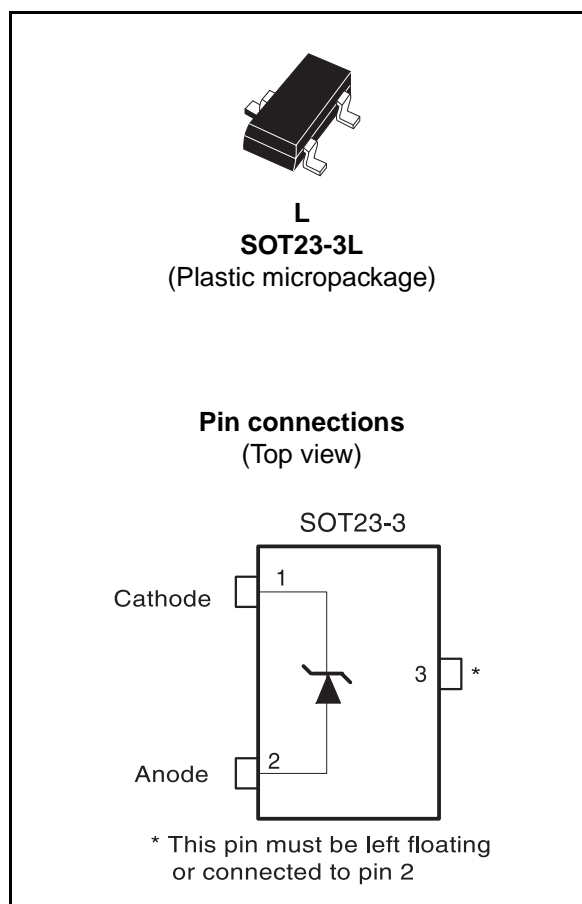
### Application

- Computers
- Instrumentation
- Battery chargers
- Switch mode power supply
- Battery operated equipments

### Description

The TS4041 is a low power shunt voltage reference providing a stable 1.225V output voltage over the industrial temperature range (-40°C to +85°C). Available in SOT23-3 surface mount package, it can be designed in applications where space saving is critical.

The low operating current is a key advantage for power restricted designs. In addition, the TS4041 is very stable and can be used in a broad range of application conditions.



# 1 Absolute maximum ratings and operating conditions

**Table 1. Absolute maximum ratings (AMR)**

| Symbol     | Parameter                                | Value       | Unit |
|------------|--|-------------|------|
| $I_k$      | Reverse breakdown current                | 20          | mA   |
| $I_f$      | Forward current                          | 10          | mA   |
| $P_d$      | Power dissipation <sup>(1)</sup> SOT23-3 | 360         | mW   |
| $T_{stg}$  | Storage temperature                      | -65 to +150 | °C   |
| ESD        | Human body model (HBM) <sup>(2)</sup>    | 2           | kV   |
|            | Machine model (MM) <sup>(3)</sup>        | 200         | V    |
| $T_{lead}$ | Lead temperature (soldering, 10 seconds) | 260         | °C   |

- $P_d$  is calculated with  $T_{amb} = 25^\circ\text{C}$  and  $T_j = 150^\circ\text{C}$  and  $R_{thja} = 340^\circ\text{C/W}$  for the SOT23-3L package.
- Human body model: 100pF discharged through a 1.5kΩ resistor between two pins of the device, done for all couples of pin combinations with other pins floating.
- Machine model: a 200pF cap is charged to the specified voltage, then discharged directly between two pins of the device with no external series resistor (internal resistor < 5Ω), done for all couples of pin combinations with other pins floating.

**Table 2. Operating conditions**

| Symbol     | Parameter                            | Value      | Unit |
|------------|--------------------------------------|------------|------|
| $I_{min}$  | Minimum operating current            | 65         | μA   |
| $I_{max}$  | Maximum operating current            | 12         | mA   |
| $T_{oper}$ | Operating free air temperature range | -40 to +85 | °C   |

## 2 Electrical characteristics

**Table 3. TS4041E (2% precision)  $T_{amb} = 25^{\circ}\text{C}$  <sup>(1)</sup> (unless otherwise specified)**

| Symbol                    | Parameter   | Test conditions   | Min.       | Typ.      | Max.       | Unit                    |
|---------------------------|---|---|------------|-----------|------------|-------------------------|
| $V_k$                     | Reverse breakdown voltage                                     | $I_k = 100\mu\text{A}$  | 1.20<br>0  | 1.22<br>5 | 1.25<br>0  | V                       |
|                           | Reverse breakdown voltage tolerance                           | $I_k = 100\mu\text{A}$<br>$-40^{\circ}\text{C} < T_{amb} < +85^{\circ}\text{C}$           | -25<br>-36 |           | +25<br>+36 | mV                      |
| $I_{k-min}$               | Minimum operating current                                     | $T_{amb} = 25^{\circ}\text{C}$  |            | 40        | 65         | $\mu\text{A}$           |
|                           |   | $-40^{\circ}\text{C} < T_{amb} < +85^{\circ}\text{C}$                                     |            |           | 70         |                         |
| $\Delta V_{ref}/\Delta T$ | Average temperature coefficient                               | $I_k = 100\mu\text{A}$  |            |           | 150        | ppm/ $^{\circ}\text{C}$ |
| $\Delta V_k/\Delta I_k$   | Reverse breakdown voltage change with operating current range | $I_{k-min} < I_k < 1\text{mA}$<br>$-40^{\circ}\text{C} < T_{amb} < +85^{\circ}\text{C}$   |            | 0.3       | 2<br>2.5   | mV                      |
|                           |   | $1\text{mA} < I_k < 12\text{mA}$<br>$-40^{\circ}\text{C} < T_{amb} < +85^{\circ}\text{C}$ |            | 2.5       | 8<br>10    |                         |
| $R_{ka}$                  | Static impedance  | $\Delta I_k = 45\mu\text{A}$ to 1mA   |            | 0.25      | 0.5        | $\Omega$                |
| $K_{vh}$                  | Long term stability   | $I_k = 100\mu\text{A}$ , $t = 1000\text{hrs}$   |            | 120       |            | ppm                     |
| $E_n$                     | Wide band noise   | $I_k = 100\mu\text{A}$ , $10\text{Hz} < f < 10\text{kHz}$                                 |            | 200       |            | nV/ $\sqrt{\text{Hz}}$  |

1. Limits are 100% production tested at 25°C. Behavior at the temperature range limits is guaranteed through correlation and by design.

**Table 4. TS4041D (1% precision)  $T_{amb} = 25^{\circ}\text{C}$  <sup>(1)</sup> (unless otherwise specified)**

| Symbol                    | Parameter   | Test conditions   | Min.       | Typ.      | Max.       | Unit                    |
|---------------------------|---|---|------------|-----------|------------|-------------------------|
| $V_k$                     | Reverse breakdown voltage                                     | $I_k = 100\mu\text{A}$  | 1.21<br>3  | 1.22<br>5 | 1.23<br>7  | V                       |
|                           | Reverse breakdown voltage tolerance                           | $I_k = 100\mu\text{A}$<br>$-40^{\circ}\text{C} < T_{amb} < +85^{\circ}\text{C}$           | -12<br>-25 |           | +12<br>+25 | mV                      |
| $I_{k-min}$               | Minimum operating current                                     | $T_{amb} = 25^{\circ}\text{C}$  |            | 40        | 65         | $\mu\text{A}$           |
|                           |   | $-40^{\circ}\text{C} < T_{amb} < +85^{\circ}\text{C}$                                     |            |           | 70         |                         |
| $\Delta V_{ref}/\Delta T$ | Average temperature coefficient                               | $I_k = 100\mu\text{A}$  |            |           | 150        | ppm/ $^{\circ}\text{C}$ |
| $\Delta V_k/\Delta I_k$   | Reverse breakdown voltage change with operating current range | $I_{k-min} < I_k < 1\text{mA}$<br>$-40^{\circ}\text{C} < T_{amb} < +85^{\circ}\text{C}$   |            | 0.3       | 2<br>2.5   | mV                      |
|                           |   | $1\text{mA} < I_k < 12\text{mA}$<br>$-40^{\circ}\text{C} < T_{amb} < +85^{\circ}\text{C}$ |            | 2.5       | 8<br>10    |                         |
| $R_{ka}$                  | Static impedance  | $\Delta I_k = 45\mu\text{A}$ to 1mA   |            | 0.25      | 0.5        | $\Omega$                |
| $K_{vh}$                  | Long term stability   | $I_k = 100\mu\text{A}$ , $t = 1000\text{hrs}$   |            | 120       |            | ppm                     |
| $E_n$                     | Wide band noise   | $I_k = 100\mu\text{A}$ , $10\text{Hz} < f < 10\text{kHz}$                                 |            | 200       |            | nV/ $\sqrt{\text{Hz}}$  |

1. Limits are 100% production tested at 25°C. Behavior at the temperature range limits is guaranteed through correlation and by design.

Table 5. TS4041C (0.5% precision) <sup>(1)</sup>  $T_{amb} = 25^{\circ}\text{C}$  (unless otherwise specified)

| Symbol                    | Parameter   | Test conditions   | Min.      | Typ.      | Max.      | Unit                    |
|---------------------------|---|---|-----------|-----------|-----------|-------------------------|
| $V_k$                     | Reverse breakdown voltage                                     | $I_k = 100\mu\text{A}$  | 1.21<br>9 | 1.22<br>5 | 1.23<br>1 | V                       |
|                           | Reverse breakdown voltage tolerance                           | $I_k = 100\mu\text{A}$<br>$-40^{\circ}\text{C} < T_{amb} < +85^{\circ}\text{C}$           | -6<br>-16 |           | +6<br>+16 | mV                      |
| $I_{k-min}$               | Minimum operating current                                     | $T_{amb} = 25^{\circ}\text{C}$  |           | 40        | 60        | $\mu\text{A}$           |
|                           |   | $-40^{\circ}\text{C} < T_{amb} < +85^{\circ}\text{C}$                                     |           |           | 65        |                         |
| $\Delta V_{ref}/\Delta T$ | Average temperature coefficient                               | $I_k = 100\mu\text{A}$  |           |           | 120       | ppm/ $^{\circ}\text{C}$ |
| $\Delta V_k/\Delta I_k$   | Reverse breakdown voltage change with operating current range | $I_{k-min} < I_k < 1\text{mA}$<br>$-40^{\circ}\text{C} < T_{amb} < +85^{\circ}\text{C}$   |           | 0.3       | 1.5<br>2  | mV                      |
|                           |   | $1\text{mA} < I_k < 12\text{mA}$<br>$-40^{\circ}\text{C} < T_{amb} < +85^{\circ}\text{C}$ |           | 2.5       | 6<br>8    |                         |
| $R_{ka}$                  | Static impedance  | $\Delta I_k = 45\mu\text{A}$ to 1mA   |           | 0.25      | 0.5       | $\Omega$                |
| $K_{vh}$                  | Long term stability   | $I_k = 100\mu\text{A}$ , $t = 1000\text{hrs}$   |           | 120       |           | ppm                     |
| $E_n$                     | Wide band noise   | $I_k = 100\mu\text{A}$ , $10\text{Hz} < f < 10\text{kHz}$                                 |           | 200       |           | nV/ $\sqrt{\text{Hz}}$  |

1. Limits are 100% production tested at 25°C. Behavior at the temperature range limits is guaranteed through correlation and by design.

Figure 1. Reference voltage versus cathode current

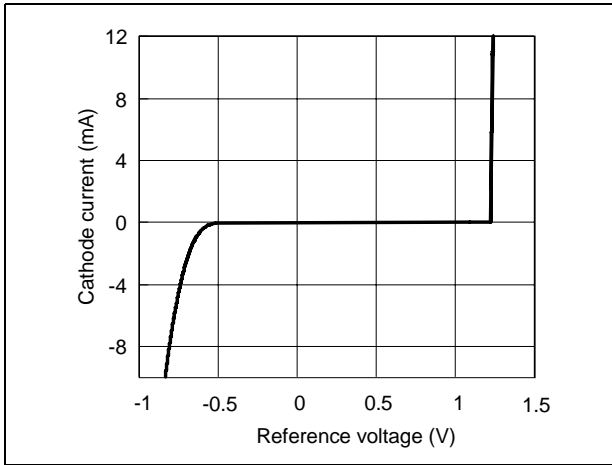


Figure 2. Reference voltage versus cathode current

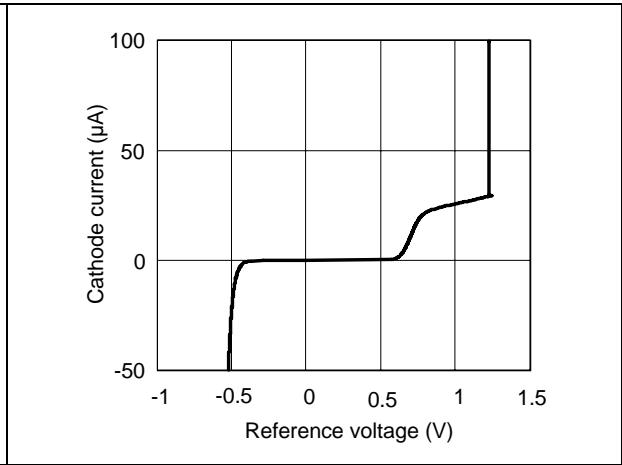


Figure 3. Test circuit

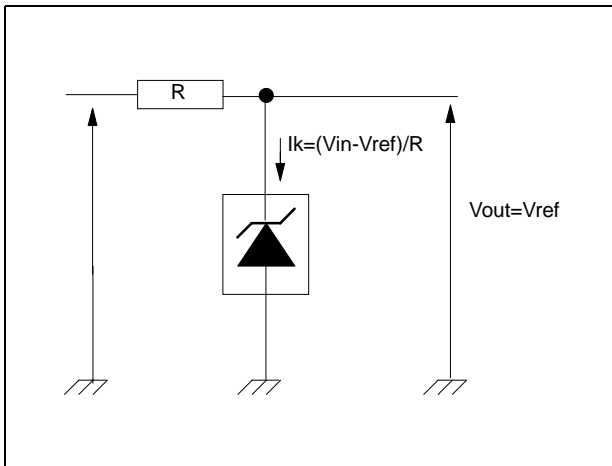


Figure 4. Reference voltage versus temperature

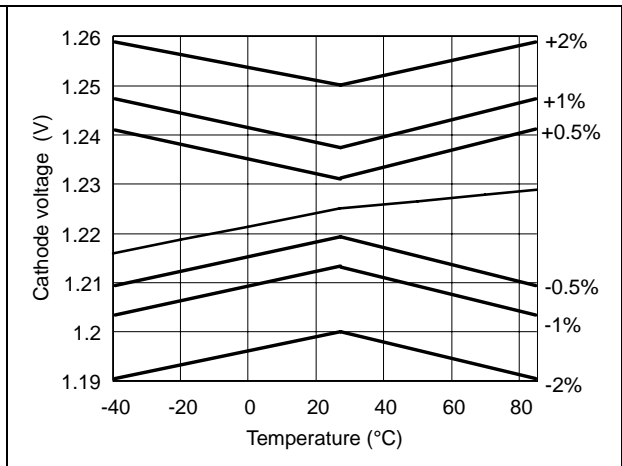


Figure 5. Static impedance versus temperature

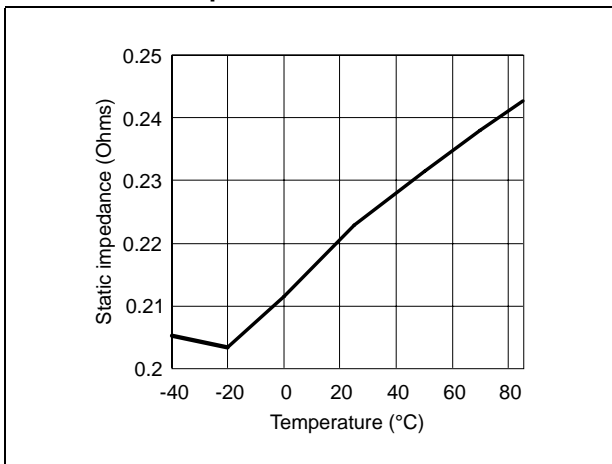


Figure 6. Noise voltage versus frequency

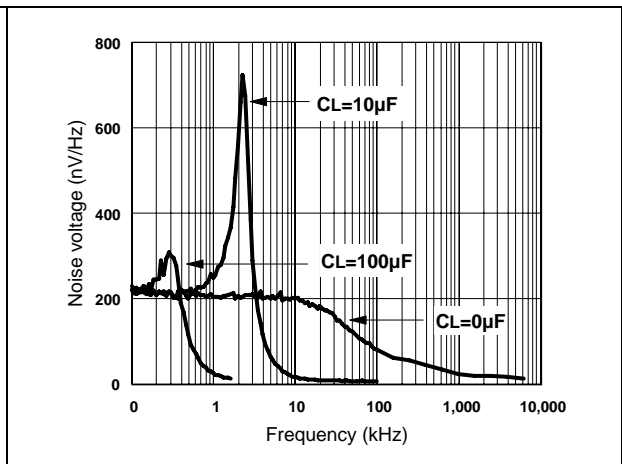


Figure 7. Pulse response for  $I_k=100\mu\text{A}$

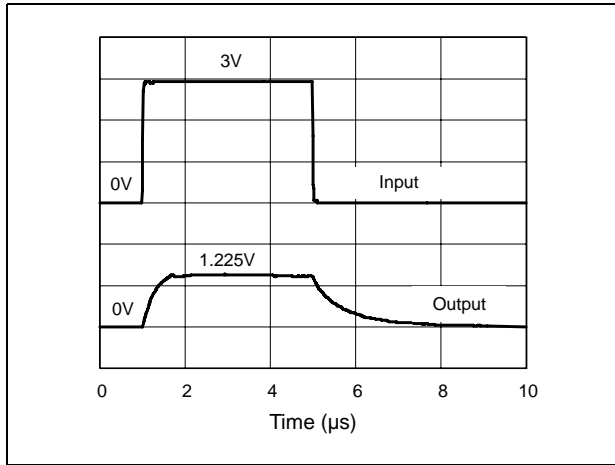


Figure 8. Test circuit for pulse response at  $I_k=100\mu\text{A}$

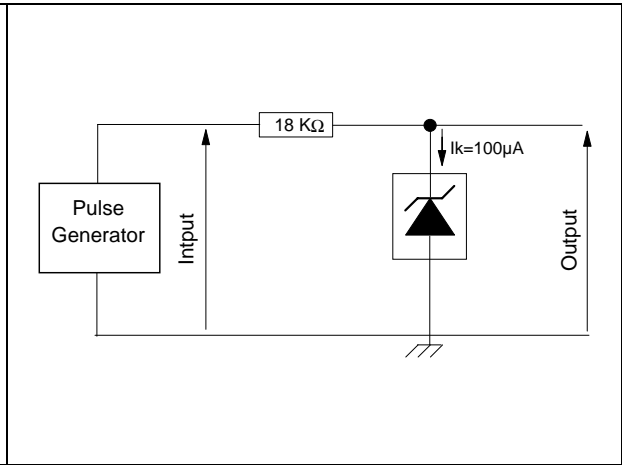


Figure 9. Pulse response for  $I_k=1\text{mA}$

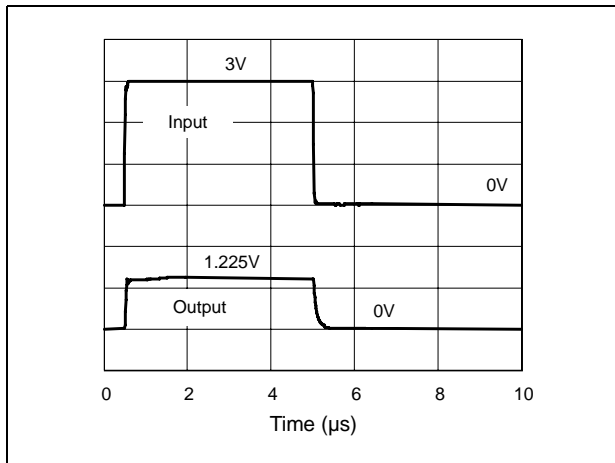
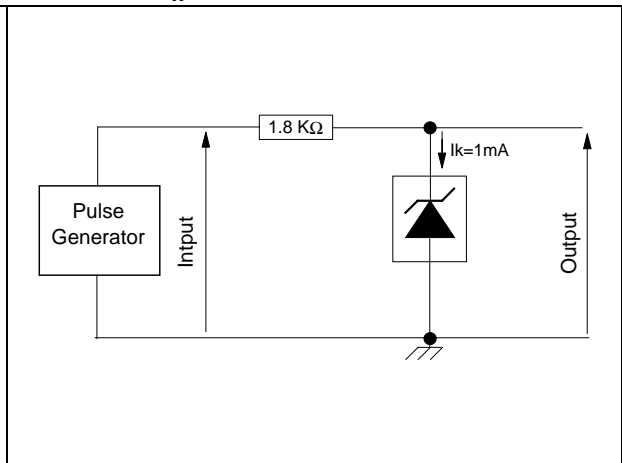


Figure 10. Test circuit for pulse response at  $I_k=1\text{mA}$

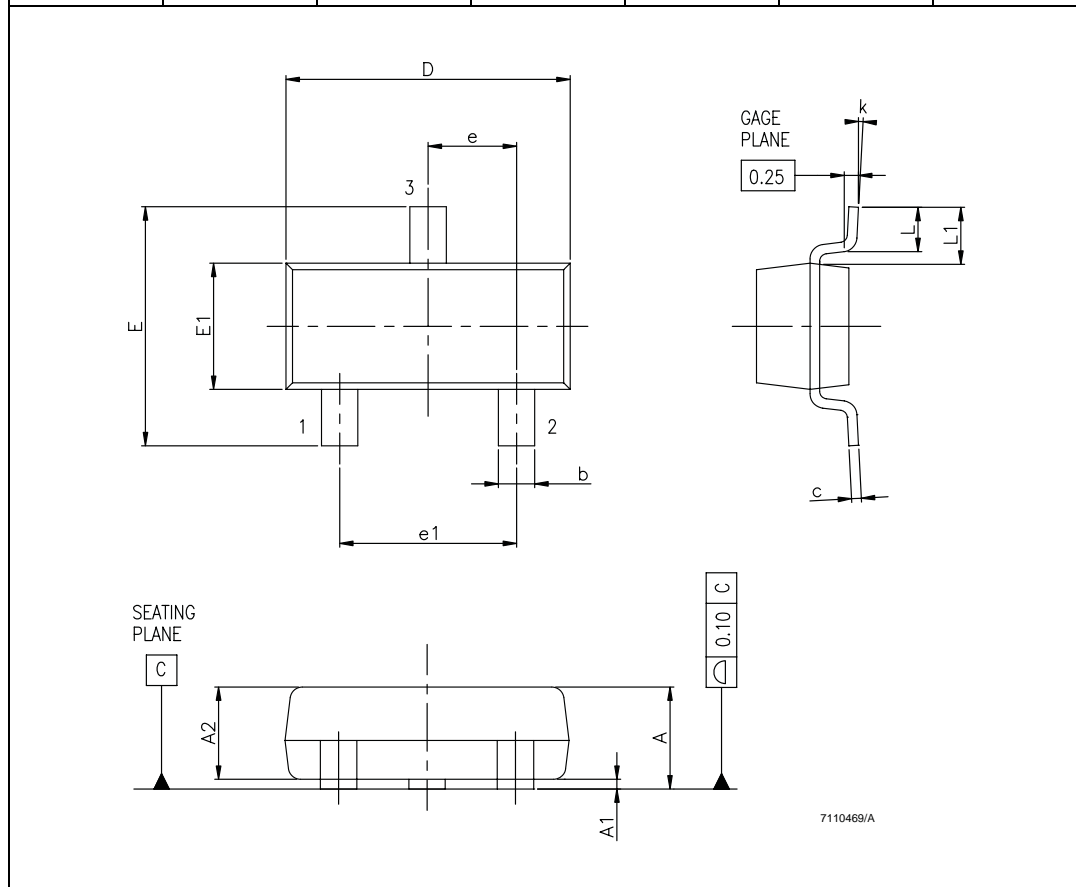


### 3 Package information

In order to meet environmental requirements, STMicroelectronics offers these devices in ECOPACK® packages. These packages have a lead-free second level interconnect. The category of second level interconnect is marked on the package and on the inner box label, in compliance with JEDEC Standard JESD97. The maximum ratings related to soldering conditions are also marked on the inner box label. ECOPACK is an STMicroelectronics trademark. ECOPACK specifications are available at: [www.st.com](http://www.st.com).

Figure 11. SOT23-3 package mechanical data

| Ref. | Dimensions  |       |       |        |        |        |
|------|-------------|-------|-------|--------|--------|--------|
|      | Millimeters |       |       | Mils   |        |        |
|      | Min.        | Typ.  | Max.  | Min.   | Typ.   | Max.   |
| A    | 0.890       |       | 1.120 | 35.05  |        | 44.12  |
| A1   | 0.010       |       | 0.100 | 0.39   |        | 3.94   |
| A2   | 0.880       | 0.950 | 1.020 | 34.65  | 37.41  | 40.17  |
| b    | 0.300       |       | 0.500 | 11.81  |        | 19.69  |
| C    | 0.080       |       | 0.200 | 3.15   |        | 7.88   |
| D    | 2.800       | 2.900 | 3.040 | 110.26 | 114.17 | 119.72 |
| E    | 2.100       |       | 2.64  | 82.70  |        | 103.96 |
| E1   | 1.200       | 1.300 | 1.400 | 47.26  | 51.19  | 55.13  |
| e    |             | 0.950 |       |        | 37.41  |        |
| e1   |             | 1.900 |       |        | 74.82  |        |
| L    | 0.400       |       | 0.600 | 15.75  |        | 23.63  |
| L1   |             | 0.540 |       |        | 21.27  |        |
| k    | 0°          |       | 8°    | 0°     |        | 8°     |



## 4 Ordering information

**Table 6. Order codes**

| Part number    | Precision | Temperature range | Package | Packing     | Marking |
|----------------|-----------|-------------------|---------|-------------|---------|
| TS4041EILT-1.2 | 2%        | -40°C to +85°C    | SOT23-3 | Tape & reel | L233    |
| TS4041DILT-1.2 | 1%        |                   |         |             | L232    |
| TS4041CILT-1.2 | 0.5%      |                   |         |             | L231    |

## 5 Revision history

**Table 7. Document revision history**

| Date        | Revision | Changes  |
|-------------|----------|--|
| 21-Mar-2002 | 1        | Initial release.                                     |
| 20-Aug-2007 | 2        | Removed TO-92 package information.<br>Format update. |



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