



TSH110-TSH111-TSH112-TSH113-TSH114

Wide band low noise operational amplifiers

Features

- Low noise: $3\text{nV}/\sqrt{\text{Hz}}$
- Low supply current: 3.2mA
- 47mA output current
- Bandwidth: 100MHz
- 5V to 12V supply voltage
- Slew rate: $450\text{V}/\mu\text{s}$
- Specified for 100Ω load
- Very low distortion
- Tiny SOT23-5, TSSOP and SO packages

Applications

- High-end video drivers
- Receiver for xDSL
- A/D converter driver
- High-end audio applications

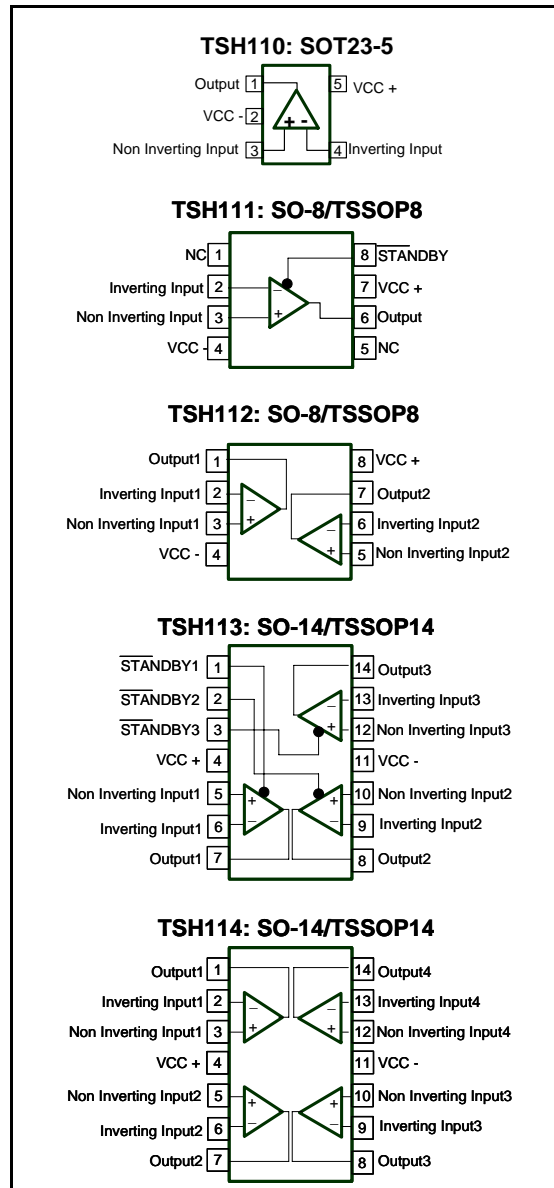
Description

The single TSH110 and TSH111, the dual TSH112, the triple TSH113 and the quad TSH114 are current feedback operational amplifiers featuring a very high slew rate of $450\text{V}/\mu\text{s}$ and a large bandwidth of 100MHz , with only a 3.2mA quiescent supply current. The TSH111 and TSH113 feature a Standby function for each operator. This function is a power-down mode with a high output impedance.

These devices operate from $\pm 2.5\text{V}$ to $\pm 6\text{V}$ dual supply voltage or from 5V to 12V single supply voltage. They are able to drive a 100Ω load with a swing of 9V minimum (for a 12V power supply).

The harmonic and intermodulation distortions of these devices are very low, making this circuit a good choice for applications requiring wide bandwidth with multiple carriers.

For board space and weight saving, the TSH110 comes in miniature SOT23-5 package.



The TSH111 comes in SO-8 and TSSOP8 packages, the TSH112 comes in SO-8 and TSSOP8 packages, the TSH113 and TSH114 come in SO-14 and TSSOP14 packages.

1 Absolute maximum ratings and operating conditions

Table 1. Absolute maximum ratings (AMR)

| Symbol | Parameter | Value | Unit |
|------------|--|-------------|------|
| V_{CC} | Supply voltage ⁽¹⁾ | 14 | V |
| V_{id} | Differential input voltage ⁽²⁾ | ±1 | V |
| V_i | Input voltage ⁽³⁾ | ±6 | V |
| T_{oper} | Operating free air temperature range | -40 to +85 | °C |
| T_{stg} | Storage temperature | -65 to +150 | °C |
| T_j | Maximum junction temperature | 150 | °C |
| R_{thjc} | Thermal resistance junction to case | | |
| | SOT23-5 | 80 | °C/W |
| | SO-8 | 28 | |
| | SO-14 | 22 | |
| | TSSOP8 | 37 | |
| TSSOP14 | 32 | | |
| R_{thja} | Thermal resistance junction to ambient area | | |
| | SOT23-5 | 250 | °C/W |
| | SO-8 | 157 | |
| | SO-14 | 125 | |
| | TSSOP8 | 130 | |
| TSSOP14 | 110 | | |
| ESD | HBM: human body model ⁽⁴⁾ | 2.0 | kV |
| | MM: machine model ⁽⁵⁾ | 0.2 | |
| | CDM: charged device model ⁽⁶⁾ | 1.5 | |
| | Output short circuit duration ⁽⁷⁾ | | |

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

Table 2. Operating conditions

| Symbol | Parameter | Value | Unit |
|-----------|---------------------------------|--------------------------------------|------|
| V_{CC} | Supply voltage | 5 to 12 | V |
| V_{icm} | Common mode input voltage range | $V_{CC}^- + 1.5$ to $V_{CC}^+ - 1.5$ | V |

2 Electrical characteristics

Table 3. Dual supply voltage, $V_{CC} = \pm 2.5V$, $R_{fb}^{(1)} = 680\Omega$, $T_{amb} = 25^\circ C$ (unless otherwise specified)

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---|---|---|------|------|------|------------------|
| DC performance | | | | | | |
| V_{io} | Input offset voltage | T_{amb} | -1.5 | 0.3 | 2.0 | mV |
| | | $T_{min} < T_{amb} < T_{max}$ | | 1 | | mV |
| ΔV_{io} | Input offset voltage drift vs. temperature | $T_{min} < T_{amb} < T_{max}$ | | 5 | | $\mu V/^\circ C$ |
| I_{ib+} | Non inverting input bias current | T_{amb} | -10 | 1.4 | 13 | μA |
| | | $T_{min} < T_{amb} < T_{max}$ | | 2.5 | | μA |
| I_{ib-} | Inverting input bias current | T_{amb} | -3 | 1.9 | 7 | μA |
| | | $T_{min} < T_{amb} < T_{max}$ | | 2.5 | | μA |
| R_{OL} | Transimpedance | $R_L = 100\Omega$ | 500 | 750 | | k Ω |
| I_{CC} | Supply current per operator | T_{amb} | | 3.2 | 4 | mA |
| | | $T_{min} < T_{amb} < T_{max}$ | | 3.5 | | mA |
| CMR | Common mode rejection ratio ($\Delta V_{ic}/\Delta V_{io}$) | | 56 | 60 | | dB |
| SVR | Supply voltage rejection ratio ($\Delta V_{CC}/\Delta V_{io}$) | | 70 | 80 | | dB |
| PSR | Power supply rejection ratio ($\Delta V_{CC}/\Delta V_{out}$) | Gain=1, $R_{load}=3.9k\Omega$ | | 48 | | dB |
| Dynamic performance and output characteristics | | | | | | |
| V_{oh} | High level output voltage | T_{amb} $R_L = 100\Omega$ | 1.4 | 2 | | V |
| | | $T_{min} < T_{amb} < T_{max}$ $R_L = 100\Omega$ GND | | 1.9 | | V |
| V_{ol} | Low level output voltage | T_{amb} $R_L = 100\Omega$ | | -1.8 | -1.3 | V |
| | | $T_{min} < T_{amb} < T_{max}$ $R_L = 100\Omega$ | | -1.7 | | V |
| $ I_{sink} $ | Output sink current | $T_{min} < T_{amb} < T_{max}$ | | 20 | | mA |
| I_{source} | Output source current | $T_{min} < T_{amb} < T_{max}$ | | 18 | | mA |
| BW | -3dB bandwidth | $V_{out}=1V_{pk}$, $R_{fb}^{(1)}=820\Omega/2pF$ Load=100 Ω | | | | |
| | | $A_{VCL}=+2$ | | 81 | | MHz |
| SR | Slew rate | $A_{VCL}=+2$, 2V step Load=100 Ω | 160 | 230 | | V/ μs |

Table 3. Dual supply voltage, $V_{CC} = \pm 2.5V$, $R_{fb}^{(1)} = 680\Omega$, $T_{amb} = 25^\circ C$ (unless otherwise specified) (continued)

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---------------------------------------|--------------------------------------|--|------|------|------|-----------------|
| T_r | Rise time | for 200mV step $A_{VCL}=+2$, $R_{fb}^{(1)}=820\Omega/2pF$ Load=100 Ω | | 9 | | ns |
| T_f | Fall time | | | 9 | | ns |
| Ov | Overshoot | | | 16 | | % |
| St | Settling time @ 0.05% | | | 60 | | ns |
| ΔG | Differential gain | $A_{VCL}=+2$, $R_L=100\Omega$ | | 0.05 | | % |
| $\Delta\phi$ | Differential phase | $F=4.5MHz$, $V_{out}=1V_{peak}$ | | 0.05 | | ° |
| Noise and harmonic performance | | | | | | |
| en | Equivalent input voltage noise | Frequency : 1MHz | | 3 | | nV/ \sqrt{Hz} |
| in | Equivalent input current noise | | | 8.5 | | pA/ \sqrt{Hz} |
| THD | Total harmonic distortion | $A_{VCL}=+2$, $F=2MHz$ $R_L=100\Omega$ $V_{out}=2V_{peak}$ | | 64.4 | | dB |
| IM3 | Third order inter modulation product | $A_{VCL}=+2$, $V_{out}=2V_{pp}$ $R_L=100\Omega$ $F1=1MHz$, $F2=1.1MHz$ | | | | dBc |
| | | @900kHz | | 90 | | |
| | | @1.2MHz | | 90 | | |
| | | @3.1MHz | | 86 | | |
| | | @3.2MHz | | 83 | | |
| Matching characteristics | | | | | | |
| Gf | Gain flatness | $F=(DC)$ to 6MHz $A_{VCL}=+2$, $V_{out}=2V_{pp}$ | | 0.1 | | dB |
| Vo1/Vo2 | Channel separation | $F=1MHz$ to 10MHz | | 65 | | dB |

1. R_{fb} is the feedback resistance between the output and the inverting input of the amplifier.

Table 4. Dual supply voltage, $V_{CC}=\pm 6V$, $R_{fb}^{(1)}=680\Omega$, $T_{amb}=25^{\circ}C$ (unless otherwise specified)

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---|---|--|------|------|------|-------------------|
| DC performance | | | | | | |
| V_{io} | Input offset voltage | T_{amb} | -1.0 | 0.9 | 3.0 | mV |
| | | $T_{min} < T_{amb} < T_{max}$ | | 1.3 | | mV |
| ΔV_{io} | Input offset voltage drift vs temperature | $T_{min} < T_{amb} < T_{max}$ | | 5 | | $\mu V/^{\circ}C$ |
| I_{ib+} | Non inverting input bias current | T_{amb} | -12 | 1 | 14 | μA |
| | | $T_{min} < T_{amb} < T_{max}$ | | 1.7 | | μA |
| I_{ib-} | Inverting input bias current | T_{amb} | -4 | 3 | 10 | μA |
| | | $T_{min} < T_{amb} < T_{max}$ | | 3.4 | | μA |
| R_{OL} | Transimpedance | $R_L=100\Omega$ | 600 | 900 | | k Ω |
| I_{CC} | Supply current per operator | T_{amb} | | 4 | 5 | mA |
| | | $T_{min} < T_{amb} < T_{max}$ | | 4.1 | | mA |
| CMR | Common mode rejection ratio ($\Delta V_{io}/\Delta V_{io}$) | | 58 | 63 | | dB |
| SVR | Supply voltage rejection ratio ($\Delta V_{CC}/\Delta V_{io}$) | | 72 | 80 | | dB |
| PSR | Power supply rejection ratio ($\Delta V_{CC}/\Delta V_{out}$) | Gain=1, $R_{load}=3.9k\Omega$ | | 49 | | dB |
| Dynamic performance and output characteristics | | | | | | |
| V_{oh} | High level output voltage | T_{amb} $R_L = 100\Omega$ | 4.5 | 4.7 | | V |
| | | $T_{min} < T_{amb} < T_{max}$ $R_L = 100\Omega$ | | 4.6 | | V |
| V_{ol} | Low level output voltage | T_{amb} $R_L = 100\Omega$ | | -4.7 | -4.3 | V |
| | | $T_{min} < T_{amb} < T_{max}$ $R_L = 100\Omega$ | | -4.6 | | V |
| $ I_{sink} $ | Output sink current | $T_{min} < T_{amb} < T_{max}$ | | 47 | | mA |
| I_{source} | Output source current | $T_{min} < T_{amb} < T_{max}$ | | 46 | | mA |
| Bw | -3dB bandwidth | $V_{out}=1V_{pk}$, $R_{fb}^{(1)}=680\Omega/2pF$ Load=100 Ω | | | | |
| | | $A_{VCL}=+2$ | | 100 | | MHz |
| SR | Slew rate | $A_{VCL}=+2$, 6V step Load=100 Ω | 240 | 450 | | V/ μs |
| T_r | Rise time | for 200mV step $A_{VCL}=+2$, $R_{fb}^{(1)}=680\Omega/2pF$ Load=100 Ω | | 10.4 | | ns |
| T_f | Fall time | | | 12.2 | | ns |
| Ov | Overshoot | | | 17 | | % |
| St | Settling time @ 0.05% | | | 40 | | ns |

Table 4. Dual supply voltage, $V_{CC}=\pm 6V$, $R_{fb}^{(1)}=680\Omega$, $T_{amb}=25^{\circ}C$ (unless otherwise specified)

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---------------------------------------|--------------------------------------|--|------|------|------|-----------------|
| ΔG | Differential gain | $A_{VCL}=+2$, $R_L=100\Omega$ $F=4.5MHz$, $V_{out}=2V_{peak}$ | | 0.05 | | % |
| $\Delta\phi$ | Differential phase | | | 0.05 | | ° |
| Noise and harmonic performance | | | | | | |
| e_n | Equivalent input voltage noise | Frequency : 1MHz | | 3 | | nV/ \sqrt{Hz} |
| i_n | Equivalent input current noise | | | 8.6 | | pA/ \sqrt{Hz} |
| THD | Total harmonic distortion | $A_{VCL}=+2$, $F=2MHz$ $R_L=100\Omega$ $V_{out}=4V_{pp}$ | | 67.7 | | dB |
| IM3 | Third order inter modulation product | $A_{VCL}=+2$, $V_{out}=4V_{pp}$ $R_L=100\Omega$ $F1=1MHz$, $F2=1.1MHz$ | | | | dBc |
| | | @900kHz | | 82 | | |
| | | @1.2MHz | | 84 | | |
| | | @3.1MHz | | 77 | | |
| | | @3.2MHz | | 73 | | |
| Matching characteristics | | | | | | |
| Gf | Gain flatness | $F=(DC)$ to 6MHz $A_{VCL}=+2$, $V_{out}=4V_{pp}$ | | 0.1 | | dB |
| $Vo1/Vo2$ | Channel separation | $F=1MHz$ to 10MHz | | 65 | | dB |

1. R_{fb} is the feedback resistance between the output and the inverting input of the amplifier.

3 Standby mode

Table 5. $T_{amb} = 25^{\circ}\text{C}$ (unless otherwise specified), $V_{CC} = \pm 6\text{V}$

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---------------|--|-------------------------------------|--------------------|----------|----------------------|------------------------|
| V_{low} | Standby low level | | V_{CC}^{-} | | $(V_{CC}^{-} + 0.8)$ | V |
| V_{high} | Standby high level | | $(V_{CC}^{-} + 2)$ | | (V_{CC}^{+}) | V |
| $I_{CC-STBY}$ | Current consumption per operator in Standby mode | | | 26 | 40 | μA |
| I_{sol} | Input/output isolation | $F=1\text{MHz}$ | | -90 | | dB |
| Z_{out} | Output impedance ($R_{out} // C_{out}$) | R_{out} C_{out} | | 31 25 | | $\text{M}\Omega$ pF |
| T_{on} | Time from Standby mode to active mode | | | 2 | | μs |
| T_{off} | Time from active mode to Standby mode | Down to $I_{CC-STBY}=40\mu\text{A}$ | | 13 | | μs |

Table 6. TSH111 standby control pin status

| TSH111 standby control pin 8 (SBY) | Operator status |
|------------------------------------|-----------------|
| V_{low} | Standby |
| V_{high} | Active |

Table 7. TSH113 standby control pin status

| TSH113 standby control | | | Operator status | | |
|------------------------|--------------------|-------------------|-----------------|---------|---------|
| pin 1 (SBY OP1) | pin 2 (SBY OP2) | pin 3 (SBY OP) | OP1 | OP1 | OP3 |
| V_{low} | x | x | Standby | x | x |
| V_{high} | x | x | Active | x | x |
| x | V_{low} | x | x | Standby | x |
| x | V_{high} | | x | Active | x |
| x | x | V_{low} | x | x | Standby |
| x | x | V_{high} | x | x | Active |

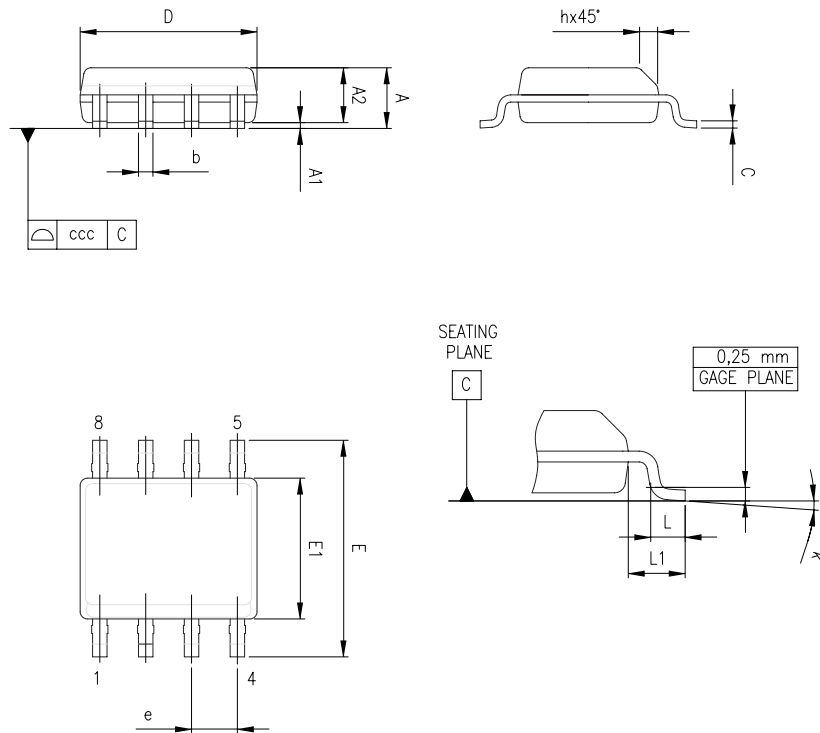
4 Package information

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.

4.1 SO-8 package mechanical data

Figure 1. SO-8 package mechanical data

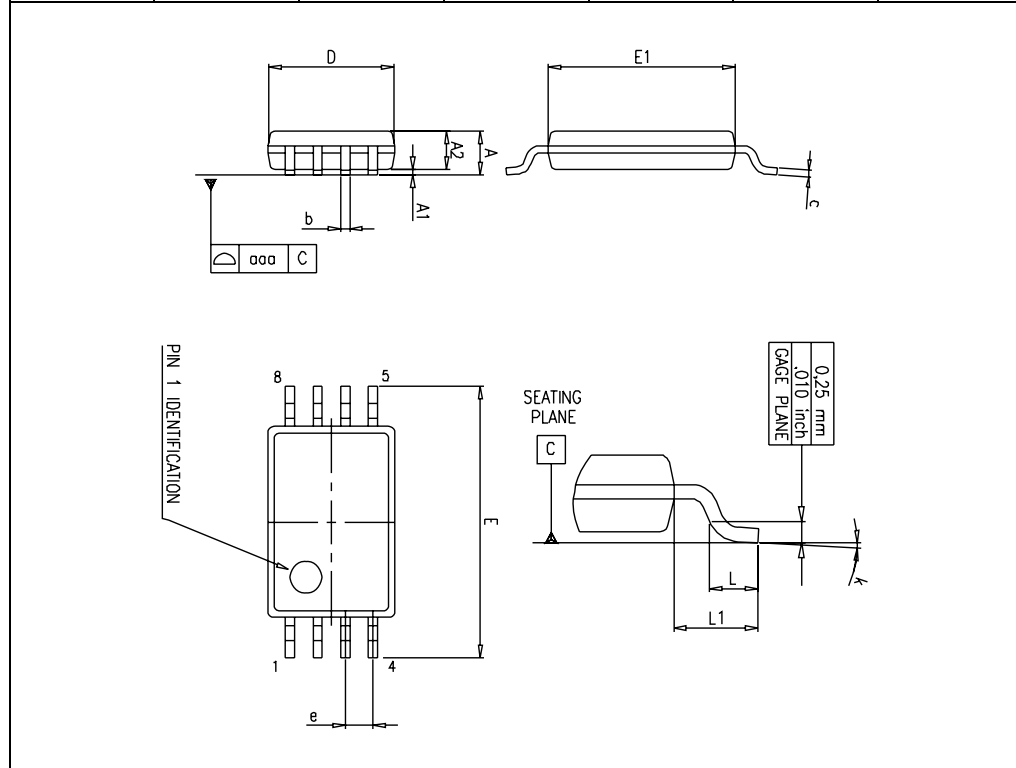
| Ref. | Dimensions | | | | | |
|------|-------------|------|------|--------|-------|-------|
| | Millimeters | | | Inches | | |
| | Min. | Typ. | Max. | Min. | Typ. | Max. |
| A | | | 1.75 | | | 0.069 |
| A1 | 0.10 | | 0.25 | 0.004 | | 0.010 |
| A2 | 1.25 | | | 0.049 | | |
| b | 0.28 | | 0.48 | 0.011 | | 0.019 |
| c | 0.17 | | 0.23 | 0.007 | | 0.010 |
| D | 4.80 | 4.90 | 5.00 | 0.189 | 0.193 | 0.197 |
| H | 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 |
| k | 1° | | 8° | 1° | | 8° |
| ccc | | | 0.10 | | | 0.004 |



4.2 TSSOP8 package mechanical data

Figure 2. TSSOP8 package mechanical data

| Ref. | Dimensions | | | | | |
|------|-------------|------|------|--------|--------|-------|
| | Millimeters | | | Inches | | |
| | Min. | Typ. | Max. | Min. | Typ. | Max. |
| A | | | 1.2 | | | 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 | | 0.1 | | | 0.004 | |



4.3 SO-14 package mechanical data

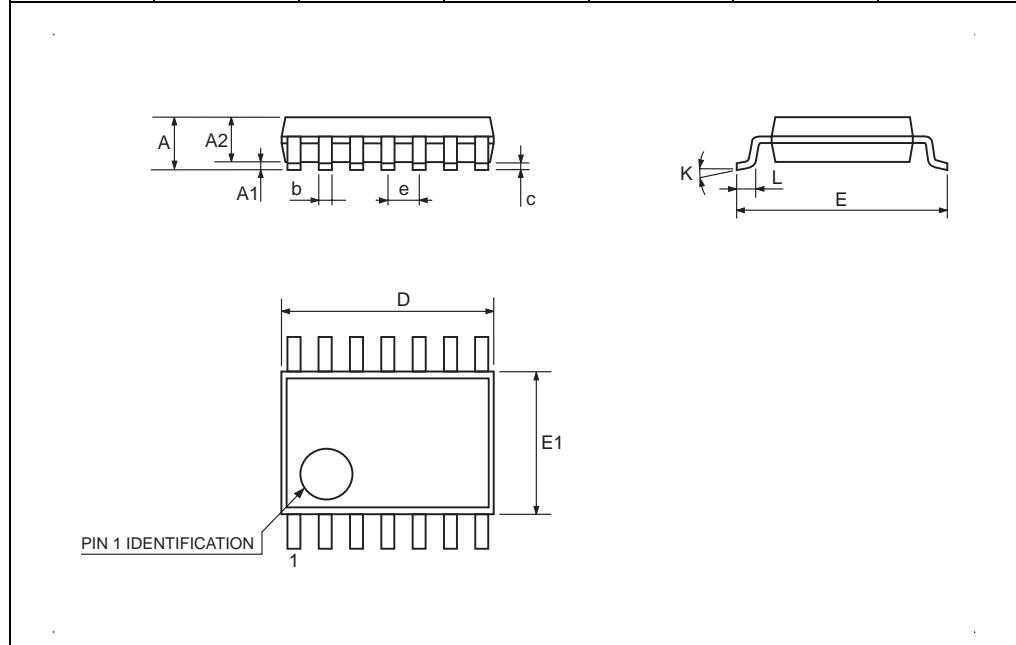
Figure 3. SO-14 package mechanical data

| Ref. | Dimensions | | | | | |
|------|-------------|------|------|--------|-------|-------|
| | Millimeters | | | Inches | | |
| | Min. | Typ. | Max. | Min. | Typ. | Max. |
| A | | | 1.75 | | | 0.068 |
| a1 | 0.1 | | 0.2 | 0.003 | | 0.007 |
| a2 | | | 1.65 | | | 0.064 |
| b | 0.35 | | 0.46 | 0.013 | | 0.018 |
| b1 | 0.19 | | 0.25 | 0.007 | | 0.010 |
| C | | 0.5 | | | 0.019 | |
| c1 | 45° (typ.) | | | | | |
| D | 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 | 3.8 | | 4.0 | 0.149 | | 0.157 |
| G | 4.6 | | 5.3 | 0.181 | | 0.208 |
| L | 0.5 | | 1.27 | 0.019 | | 0.050 |
| M | | | 0.68 | | | 0.026 |
| S | 8° (max.) | | | | | |

4.4 TSSOP14 package mechanical data

Figure 4. TSSOP14 package mechanical data

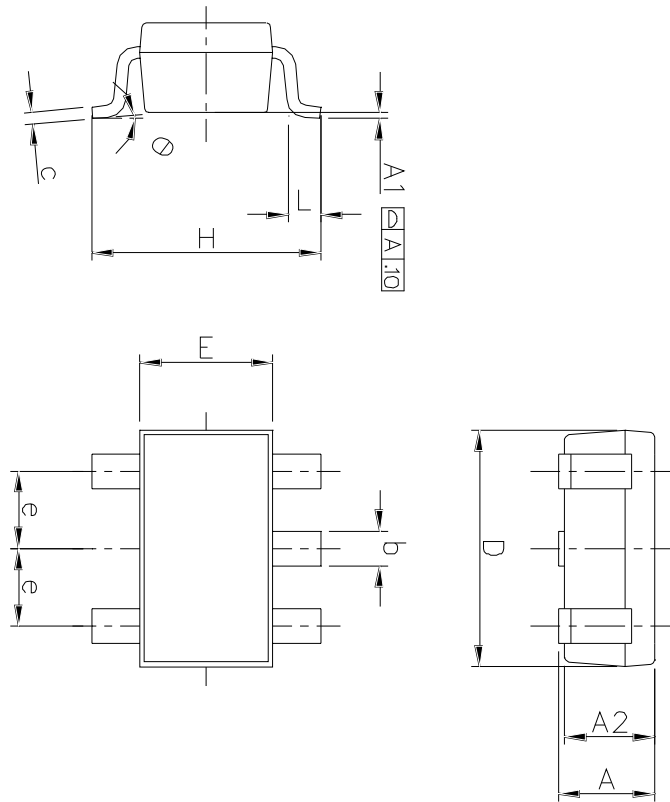
| Ref. | Dimensions | | | | | |
|------|-------------|----------|------|--------|------------|--------|
| | Millimeters | | | Inches | | |
| | Min. | Typ. | Max. | Min. | Typ. | Max. |
| A | | | 1.2 | | | 0.047 |
| A1 | 0.05 | | 0.15 | 0.002 | 0.004 | 0.006 |
| A2 | 0.8 | 1 | 1.05 | 0.031 | 0.039 | 0.041 |
| b | 0.19 | | 0.30 | 0.007 | | 0.012 |
| c | 0.09 | | 0.20 | 0.004 | | 0.0089 |
| D | 4.9 | 5 | 5.1 | 0.193 | 0.197 | 0.201 |
| E | 6.2 | 6.4 | 6.6 | 0.244 | 0.252 | 0.260 |
| E1 | 4.3 | 4.4 | 4.48 | 0.169 | 0.173 | 0.176 |
| e | | 0.65 BSC | | | 0.0256 BSC | |
| K | 0° | | 8° | 0° | | 8° |
| L | 0.45 | 0.60 | 0.75 | 0.018 | 0.024 | 0.030 |



4.5 SOT23-5 package mechanical data

Figure 5. SOT23-5 package (Inches)

| Ref. | Dimensions | | | | | |
|------|-------------|------|------|--------|-------|-------|
| | Millimeters | | | Inches | | |
| | Min. | Typ. | Max. | Min. | Typ. | Max. |
| A | 0.90 | | 1.45 | 0.035 | | 0.057 |
| A1 | 0.00 | | 0.15 | 0.00 | | 0.006 |
| A2 | 0.90 | | 1.30 | 0.035 | | 0.051 |
| b | 0.35 | | 0.50 | 0.014 | | 0.02 |
| C | 0.09 | | 0.20 | 0.003 | | 0.008 |
| D | 2.80 | | 3.00 | 0.110 | | 0.118 |
| H | 2.60 | | 3.00 | 0.102 | | 0.118 |
| E | 1.50 | | 1.75 | 0.059 | | 0.069 |
| e | | 0.95 | | | 0.037 | |
| e1 | | 1.9 | | | 0.075 | |
| L | 0.35 | | 0.55 | 0.014 | | 0.022 |



5 Ordering information

Table 8. Order codes

| Part number | Temperature range | Package | Packing | Marking |
|---------------------------|-------------------|---|------------------------|---------|
| TSH110ILT | -40°C to +85°C | SOT23-5 | Tape & reel | K302 |
| TSH110IYLT ⁽¹⁾ | | SOT23-5 (Automotive grade level) | Tape & reel | K309 |
| TSH111ID TSH111IDT | | SO-8 | Tube or Tape & reel | H111I |
| TSH111IPT | | TSSOP8 (Thin shrink outline package) | Tape & reel | H111I |
| TSH112ID TSH112IDT | | SO-8 | Tube or Tape & reel | H112I |
| TSH112IPT | | TSSOP8 (Thin shrink outline package) | Tape & reel | H112I |
| TSH113ID TSH113IDT | | SO-14 | Tube or Tape & reel | TSH113I |
| TSH113IPT | | TSSOP14 | Tape & reel | TSH113I |
| TSH114ID TSH114IDT | | SO-14 | Tube or Tape & reel | TSH114I |
| TSH114IPT | | TSSOP14 | Tape & reel | TSH114I |

1. Qualification and characterization according to AEC Q100 and Q003 or equivalent, advanced screening according to AEC Q001 & Q 002 or equivalent are on-going.

6 Revision history

Table 9. Document revision history

| Date | Revision | Changes |
|-------------|----------|---|
| 4-Oct-2001 | 1 | Initial release. |
| 22-Oct-2007 | 2 | Added TSH110ILT/TSH110IYLT order codes to Table 8: Order codes . Document reformatted. |

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