



TSV6390, TSV6390A, TSV6391, TSV6391A

Micropower (60 μ A), wide bandwidth (2.4 MHz) CMOS op-amps

Features

- Low offset voltage: 500 μ V max (A version)
- Low power consumption: 60 μ A typ at 5 V
- Low supply voltage: 1.5 V – 5.5 V
- Gain bandwidth product: 2.4 MHz typical
- Stable in gain configuration (-3 or +4)
- Low power shutdown mode: 5 nA typical
- High output current: 63 mA at $V_{CC} = 5$ V
- Low input bias current: 1 pA typical
- Rail-to-rail input and output
- Extended temperature range: -40°C to +125°C
- 4 kV human body model

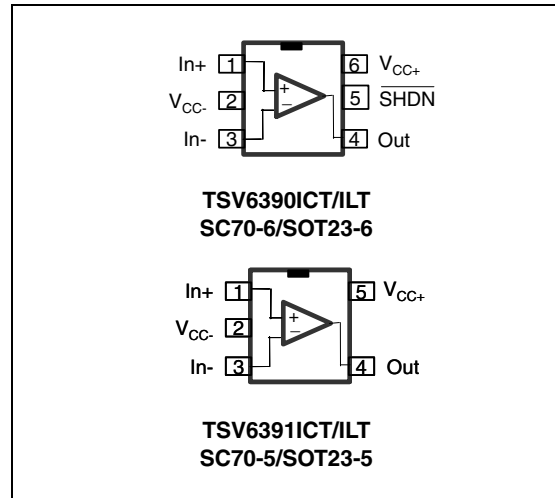
Applications

- Battery-powered applications
- Portable devices
- Signal conditioning
- Active filtering
- Medical instrumentation

Description

The TSV6390 and TSV6391 devices are single operational amplifiers offering low voltage, low power operation and rail-to-rail input and output.

With a very low input bias current and low offset voltage (500 μ V maximum for the A version), the TSV6390 and TSV6391 are ideal for applications requiring precision. The devices can operate at power supplies ranging from 1.5 to 5.5 V, and are therefore ideal for battery-powered devices, extending battery life.



When used with a gain (above -3 or +4), these products feature an excellent speed/power consumption ratio, offering a 2.4 MHz gain bandwidth product while consuming only 60 μ A at a 5 V supply voltage.

The TSV6390 comes with a shutdown function.

Both the TSV6390 and TSV6391 have a high tolerance to ESD, sustaining 4 kV for the human body model.

Additionally, they are offered in micropackages, SC70-6 and SOT23-6 for the TSV6390 and SC70-5 and SOT23-5 for the TSV6391. They are guaranteed for industrial temperature ranges from -40° C to +125° C.

All these features combined make the TSV6390 and TSV6391 ideal for sensor interfaces, battery-supplied and portable applications, as well as active filtering.

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1 Absolute maximum ratings and operating conditions

Table 1. Absolute maximum ratings (AMR)

| Symbol | Parameter | Value | Unit |
|-------------------|--|-----------------------------------|------|
| V_{CC} | Supply voltage ⁽¹⁾ | 6 | V |
| V_{id} | Differential input voltage ⁽²⁾ | $\pm V_{CC}$ | V |
| V_{in} | Input voltage ⁽³⁾ | $V_{CC} - 0.2$ to $V_{CC+} + 0.2$ | V |
| I_{in} | Input current ⁽⁴⁾ | 10 | mA |
| \overline{SHDN} | Shutdown voltage ⁽³⁾ | $V_{CC} - 0.2$ to $V_{CC+} + 0.2$ | V |
| T_{stg} | Storage temperature | -65 to +150 | °C |
| R_{thja} | Thermal resistance junction to ambient ⁽⁵⁾⁽⁶⁾ | | °C/W |
| | SC70-5 | 205 | |
| | SOT23-5 | 250 | |
| | SOT23-6 | 240 | |
| | SC70-6 | 232 | |
| T_j | Maximum junction temperature | 150 | °C |
| ESD | HBM: human body model ⁽⁷⁾ | 4 | kV |
| | MM: machine model ⁽⁸⁾ | 300 | V |
| | CDM: charged device model ⁽⁹⁾ | 1.5 | kV |
| | Latch-up immunity | 200 | mA |

- All voltage values, except differential voltages, are with respect to network ground terminal.
- Differential voltages are the non-inverting input terminal with respect to the inverting input terminal.
- $V_{CC} - V_{in}$ must not exceed 6 V, V_{in} must not exceed 6 V.
- Input current must be limited by a resistor in series with the inputs.
- Short-circuits can cause excessive heating and destructive dissipation.
- R_{th} are typical values.
- Human body model: 100 pF discharged through a 1.5 k Ω resistor between two pins of the device, done for all couples of pin combinations with other pins floating.
- 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 Ω), done for all couples of pin combinations with other pins floating.
- Charged device model: all pins plus package are charged together to the specified voltage and then discharged directly to the ground.

Table 2. Operating conditions

| Symbol | Parameter | Value | Unit |
|------------|--------------------------------------|-----------------------------------|------|
| V_{CC} | Supply voltage | 1.5 to 5.5 | V |
| V_{icm} | Common mode input voltage range | $V_{CC} - 0.1$ to $V_{CC+} + 0.1$ | V |
| T_{oper} | Operating free air temperature range | -40 to +125 | °C |

2 Electrical characteristics

Table 3. Electrical characteristics at $V_{CC+} = +1.8\text{ V}$ with $V_{CC-} = 0\text{ V}$, $V_{icm} = V_{CC}/2$, $T_{amb} = 25^\circ\text{ C}$ and R_L connected to $V_{CC}/2$ (unless otherwise specified)

| Symbol | Parameter | Conditions | Min. | Typ. | Max. | Unit |
|-----------------------|---|---|------|----------|----------|--------------------------------------|
| DC performance | | | | | | |
| V_{io} | Offset voltage | TSV6390-TSV6391 TSV6390A-TSV6391A | | | 3 0.5 | mV |
| | | $T_{min} < T_{op} < T_{max}$ TSV6390-TSV6391 TSV6390A-TSV6391A | | | 4.5 2 | |
| DV_{io} | Input offset voltage drift | | | 2 | | $\mu\text{V}/^\circ\text{C}$ |
| I_{io} | Input offset current ⁽¹⁾ ($V_{out} = V_{CC}/2$) | | | 1 | 10 | pA |
| | | $T_{min} < T_{op} < T_{max}$ | | 1 | 100 | |
| I_{ib} | Input bias current ⁽¹⁾ ($V_{out} = V_{CC}/2$) | | | 1 | 10 | pA |
| | | $T_{min} < T_{op} < T_{max}$ | | 1 | 100 | |
| CMR | Common mode rejection ratio $20 \log(\Delta V_{ic}/\Delta V_{io})$ | 0 V to 1.8 V, $V_{out} = 0.9\text{ V}$ | 53 | 74 | | dB |
| | | $T_{min} < T_{op} < T_{max}$ | 51 | | | |
| A_{vd} | Large signal voltage gain | $R_L = 10\text{ k}\Omega$, $V_{out} = 0.5\text{ V to }1.3\text{ V}$ | 85 | 95 | | dB |
| | | $T_{min} < T_{op} < T_{max}$ | 80 | | | |
| V_{OH} | High level output voltage | $R_L = 10\text{ k}\Omega$ | 35 | 5 | | mV |
| | | $T_{min} < T_{op} < T_{max}$ | 50 | | | |
| V_{OL} | Low level output voltage | $R_L = 10\text{ k}\Omega$ | | 4 | 35 | mV |
| | | $T_{min} < T_{op} < T_{max}$ | | | 50 | |
| I_{out} | I_{sink} | $V_{out} = 1.8\text{ V}$ | 6 | 12 | | mA |
| | | $T_{min} < T_{op} < T_{max}$ | 4 | | | |
| | I_{source} | $V_{out} = 0\text{ V}$ | 6 | 10 | | mA |
| | | $T_{min} < T_{op} < T_{max}$ | 4 | | | |
| I_{CC} | Supply current SHDN = V_{CC} | No load, $V_{out} = V_{CC}/2$ | 40 | 50 | 60 | μA |
| | | $T_{min} < T_{op} < T_{max}$ | | | 62 | |
| AC performance | | | | | | |
| GBP | Gain bandwidth product | $R_L = 10\text{ k}\Omega$, $C_L = 100\text{ pF}$ | | 2 | | MHz |
| Gain | Minimum gain for stability | Phase margin = 60° , $R_f = 10\text{ k}\Omega$, $R_L = 10\text{ k}\Omega$, $C_L = 20\text{ pF}$ | | +4 -3 | | V/V |
| SR | Slew rate | $R_L = 10\text{ k}\Omega$, $C_L = 100\text{ pF}$, $V_{out} = 0.5\text{ V to }1.3\text{ V}$ | | 0.7 | | V/ μs |
| e_n | Equivalent input noise voltage | $f = 1\text{ kHz}$ | | 60 | | $\frac{\text{nV}}{\sqrt{\text{Hz}}}$ |
| | | $f = 10\text{ kHz}$ | | 33 | | |

1. Guaranteed by design.

Table 4. Shutdown characteristics $V_{CC} = 1.8\text{ V}$ (TSV6390)

| Symbol | Parameter | Conditions | Min. | Typ. | Max. | Unit |
|-----------------------|---|---|------|------|------|---------------|
| DC performance | | | | | | |
| I_{CC} | Supply current in shutdown mode (all operators) | $\overline{\text{SHDN}} = V_{CC-}$ | | 2.5 | 50 | nA |
| | | $T_{\min} < T_{op} < 85^\circ\text{C}$ | | | 200 | nA |
| | | $T_{\min} < T_{op} < 125^\circ\text{C}$ | | | 1.5 | μA |
| t_{on} | Amplifier turn-on time | $R_L = 2\text{ k}\Omega$ $V_{out} = V_{CC-}$ to $V_{CC+} + 0.2\text{ V}$ | | 300 | | ns |
| t_{off} | Amplifier turn-off time | $R_L = 2\text{ k}\Omega$, $V_{out} = V_{CC+} - 0.5\text{ V}$ to $V_{CC+} - 0.7\text{ V}$ | | 20 | | ns |
| V_{IH} | $\overline{\text{SHDN}}$ logic high | | 1.3 | | | V |
| V_{IL} | $\overline{\text{SHDN}}$ logic low | | | | 0.5 | V |
| I_{IH} | $\overline{\text{SHDN}}$ current high | $\overline{\text{SHDN}} = V_{CC+}$ | | 10 | | μA |
| I_{IL} | $\overline{\text{SHDN}}$ current low | $\overline{\text{SHDN}} = V_{CC-}$ | | 10 | | μA |
| I_{OLeak} | Output leakage in shutdown mode | $\overline{\text{SHDN}} = V_{CC-}$ | | 50 | | μA |
| | | $T_{\min} < T_{op} < T_{\max}$ | | 1 | | nA |

Table 5. $V_{CC+} = +3.3\text{ V}$, $V_{CC-} = 0\text{ V}$, $V_{icm} = V_{CC}/2$, $T_{amb} = 25^\circ\text{ C}$, R_L connected to $V_{CC}/2$
(unless otherwise specified)

| Symbol | Parameter | Conditions | Min. | Typ. | Max. | Unit |
|-----------------------|---|---|------|----------|----------|--------------------------------------|
| DC performance | | | | | | |
| V_{io} | Offset voltage | TSV6390-TSV6391 TSV6390A-TSV6391A | | | 3 0.5 | mV |
| | | $T_{min} < T_{op} < T_{max}$ TSV6390-TSV6391 TSV6390A-TSV6391A | | | 4.5 2 | |
| DV_{io} | Input offset voltage drift | | | 2 | | $\mu\text{V}/^\circ\text{C}$ |
| I_{io} | Input offset current ⁽¹⁾ | | | 1 | 10 | pA |
| | | $T_{min} < T_{op} < T_{max}$ | | 1 | 100 | |
| I_{ib} | Input bias current ⁽¹⁾ | | | 1 | 10 | pA |
| | | $T_{min} < T_{op} < T_{max}$ | | 1 | 100 | |
| CMR | Common mode rejection ratio $20 \log (\Delta V_{ic}/\Delta V_{io})$ | 0 V to 3.3 V, $V_{out} = 1.65\text{ V}$ | 57 | 79 | | dB |
| | | $T_{min} < T_{op} < T_{max}$ | 53 | | | |
| A_{vd} | Large signal voltage gain | $R_L = 10\text{ k}\Omega$, $V_{out} = 0.5\text{ V to }2.8\text{ V}$ | 88 | 98 | | dB |
| | | $T_{min} < T_{op} < T_{max}$ | 83 | | | |
| V_{OH} | High level output voltage | $R_L = 10\text{ k}\Omega$ | 35 | 6 | | mV |
| | | $T_{min.} < T_{op} < T_{max}$ | 50 | | | |
| V_{OL} | Low level output voltage | $R_L = 10\text{ k}\Omega$ | | 7 | 35 | mV |
| | | $T_{min} < T_{op} < T_{max}$ | | | 50 | |
| I_{out} | I_{sink} | $V_{out} = 3.3\text{ V}$ | 23 | 45 | | mA |
| | | $T_{min} < T_{op} < T_{max}$ | 20 | 42 | | |
| | I_{source} | $V_{out} = 0\text{ V}$ | 23 | 38 | | mA |
| | | $T_{min} < T_{op} < T_{max}$ | 20 | | | |
| I_{CC} | Supply current $\overline{\text{SHDN}} = V_{CC}$ | No load, $V_{out} = V_{CC}/2$ | 43 | 55 | 64 | μA |
| | | $T_{min} < T_{op} < T_{max}$ | | | 66 | μA |
| AC performance | | | | | | |
| GBP | Gain bandwidth product | $R_L = 10\text{ k}\Omega$, $C_L = 100\text{ pF}$ | | 2.2 | | MHz |
| Gain | Minimum gain for stability | Phase margin = 60° , $R_f = 10\text{ k}\Omega$, $R_L = 10\text{ k}\Omega$, $C_L = 20\text{ pF}$, | | +4 -3 | | V/V |
| SR | Slew rate | $R_L = 10\text{ k}\Omega$, $C_L = 100\text{ pF}$, $V_{out} = 0.5\text{ V to }2.8\text{ V}$ | | 0.9 | | V/ μs |
| e_n | Equivalent input noise voltage | $f = 1\text{ kHz}$ | | 65 | | $\frac{\text{nV}}{\sqrt{\text{Hz}}}$ |

1. Guaranteed by design.

Table 6. Electrical characteristics at $V_{CC+} = +5\text{ V}$ with $V_{CC-} = 0\text{ V}$, $V_{icm} = V_{CC}/2$, $T_{amb} = 25^\circ\text{ C}$ and R_L connected to $V_{CC}/2$ (unless otherwise specified)

| Symbol | Parameter | Conditions | Min. | Typ. | Max. | Unit |
|-----------------------|---|---|------|----------|----------|------------------------------|
| DC performance | | | | | | |
| V_{io} | Offset voltage | TSV6390-TSV6391 TSV6390A-TSV6391A | | | 3 0.5 | mV |
| | | $T_{min} < T_{op} < T_{max}$ TSV6390-TSV6391 TSV6390A-TSV6391A | | | 4.5 2 | mV |
| DV_{io} | Input offset voltage drift | | | 2 | | $\mu\text{V}/^\circ\text{C}$ |
| I_{io} | Input offset current ⁽¹⁾ ($V_{out} = V_{CC}/2$) | | | 1 | 10 | pA |
| | | $T_{min} < T_{op} < T_{max}$ | | 1 | 100 | |
| I_{ib} | Input bias current ⁽¹⁾ ($V_{out} = V_{CC}/2$) | | | 1 | 10 | pA |
| | | $T_{min} < T_{op} < T_{max}$ | | 1 | 100 | |
| CMR | Common mode rejection ratio $20 \log (\Delta V_{ic}/\Delta V_{io})$ | 0 V to 5 V, $V_{out} = 2.5\text{ V}$ | 60 | 80 | | dB |
| | | $T_{min} < T_{op} < T_{max}$ | 55 | | | |
| SVR | Supply voltage rejection ratio $20 \log (\Delta V_{CC}/\Delta V_{io})$ | $V_{CC} = 1.8\text{ to }5\text{ V}$ | 75 | 93 | | dB |
| | | $T_{min} < T_{op} < T_{max}$ | 73 | | | |
| A_{vd} | Large signal voltage gain | $R_L = 10\text{ k}\Omega$, $V_{out} = 0.5\text{ V to }4.5\text{ V}$ | 89 | 98 | | dB |
| | | $T_{min} < T_{op} < T_{max}$ | 84 | | | |
| V_{OH} | High level output voltage | $R_L = 10\text{ k}\Omega$ | 35 | 7 | | mV |
| | | $T_{min} < T_{op} < T_{max}$ | 50 | | | |
| V_{OL} | Low level output voltage | $R_L = 10\text{ k}\Omega$ | | 6 | 35 | mV |
| | | $T_{min} < T_{op} < T_{max}$ | | | 50 | |
| I_{out} | I_{sink} | $V_{out} = 5\text{ V}$ | 40 | 65 | | mA |
| | | $T_{min} < T_{op} < T_{max}$ | 35 | | | |
| | I_{source} | $V_{out} = 0\text{ V}$ | 40 | 72 | | mA |
| | | $T_{min} < T_{op} < T_{max}$ | 35 | | | |
| I_{CC} | Supply current SHDN = V_{CC} | No load, $V_{out} = V_{CC}/2$ | 50 | 60 | 69 | μA |
| | | $T_{min} < T_{op} < T_{max}$ | | | 72 | |
| AC performance | | | | | | |
| GBP | Gain bandwidth product | $R_L = 10\text{ k}\Omega$, $C_L = 100\text{ pF}$ | | 2.4 | | MHz |
| Gain | Minimum gain for stability | Phase margin = 60° , $R_f = 10\text{ k}\Omega$, $R_L = 10\text{ k}\Omega$, $C_L = 20\text{ pF}$, | | +4 -3 | | V/V |
| SR | Slew rate | $R_L = 10\text{ k}\Omega$, $C_L = 100\text{ pF}$ | | 1.1 | | V/ μs |

Table 6. Electrical characteristics at $V_{CC+} = +5\text{ V}$ with $V_{CC-} = 0\text{ V}$, $V_{icm} = V_{CC}/2$, $T_{amb} = 25^\circ\text{ C}$ and R_L connected to $V_{CC}/2$ (unless otherwise specified) (continued)

| Symbol | Parameter | Conditions | Min. | Typ. | Max. | Unit |
|--------|-----------------------------------|--|------|----------|------|------------------------|
| e_n | Equivalent input noise voltage | $f = 1\text{ kHz}$ $f = 10\text{ kHz}$ | | 60 33 | | $\frac{nV}{\sqrt{Hz}}$ |
| THD+N | Total harmonic distortion + noise | $A_v = -10$, $f_{in} = 1\text{ kHz}$, $R = 100\text{ k}\Omega$, $V_{icm} = V_{CC}/2$, $V_{in} = 40\text{ mVpp}$ | | 0.11 | | % |

1. Guaranteed by design.

Table 7. Shutdown characteristics $V_{CC} = 5\text{ V}$ (TSV6390)

| Symbol | Parameter | Conditions | Min. | Typ. | Max. | Unit |
|-----------------------|---|--|------|------|------|---------------|
| DC performance | | | | | | |
| I_{CC} | Supply current in shutdown mode (all operators) | $\overline{SHDN} = V_{CC-}$ | | 5 | 50 | nA |
| | | $T_{min} < T_{op} < 85^\circ\text{ C}$ | | | 200 | nA |
| | | $T_{min} < T_{op} < 125^\circ\text{ C}$ | | | 1.5 | μA |
| t_{on} | Amplifier turn-on time | $R_L = 2\text{ k}\Omega$ $V_{out} = V_{CC-}$ to $V_{CC-} + 0.2\text{ V}$ | | 300 | | ns |
| t_{off} | Amplifier turn-off time | $R_L = 2\text{ }\Omega$, $V_{out} = V_{CC+} - 0.5\text{ V}$ to $V_{CC+} - 0.7\text{ V}$ | | 30 | | ns |
| V_{IH} | \overline{SHDN} logic high | | 4.5 | | | V |
| V_{IL} | \overline{SHDN} logic low | | | | 0.5 | V |
| I_{IH} | \overline{SHDN} current high | $\overline{SHDN} = V_{CC+}$ | | 10 | | μA |
| I_{IL} | \overline{SHDN} current low | $\overline{SHDN} = V_{CC-}$ | | 10 | | μA |
| I_{OLeak} | Output leakage in shutdown mode | $\overline{SHDN} = V_{CC-}$ | | 50 | | μA |
| | | $T_{min} < T_{op} < T_{max}$ | | 1 | | nA |

Figure 1. Supply current vs. supply voltage at $V_{icm} = V_{CC}/2$

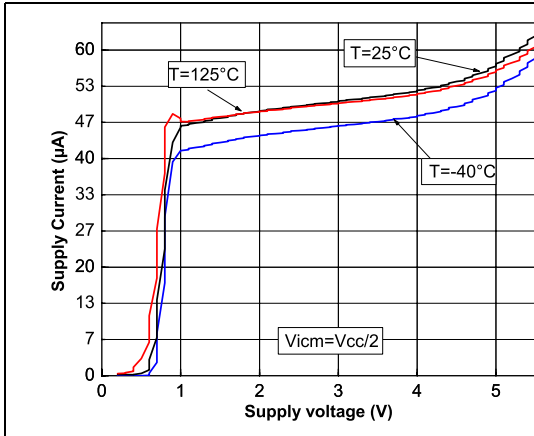


Figure 2. Output current vs. output voltage at $V_{CC} = 1.5 V$

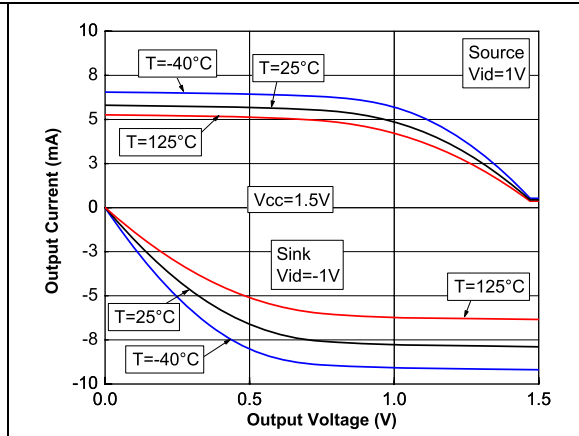


Figure 3. Output current vs. output voltage at $V_{CC} = 5 V$

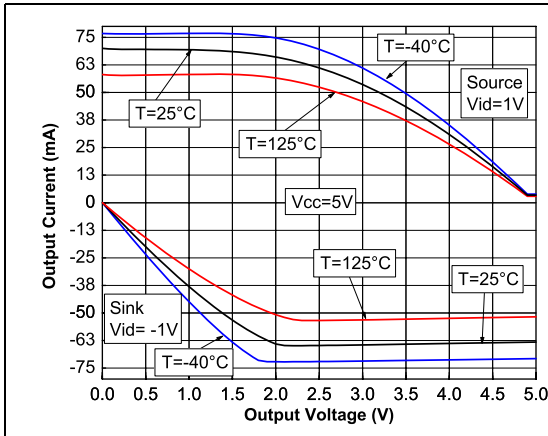


Figure 4. Peaking at closed loop gain = -10

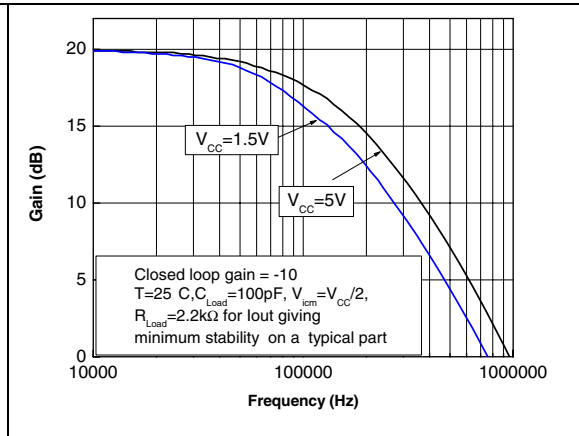


Figure 5. Peaking at closed loop gain = -3 at $V_{CC} = 1.5 V$

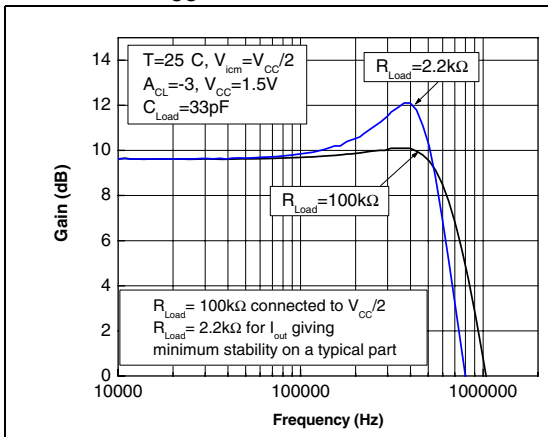


Figure 6. Peaking at closed loop gain = -3 at $V_{CC} = 5 V$

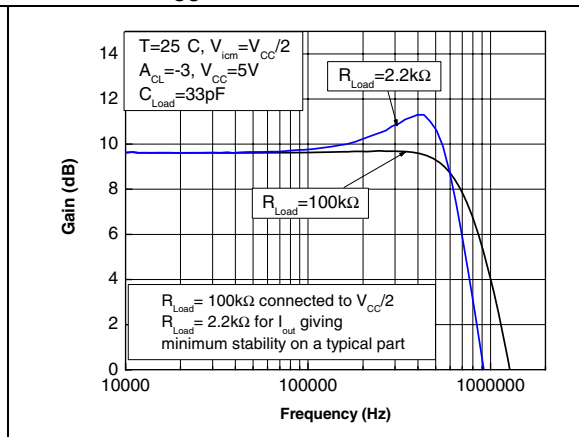


Figure 7. Positive slew rate vs. supply voltage

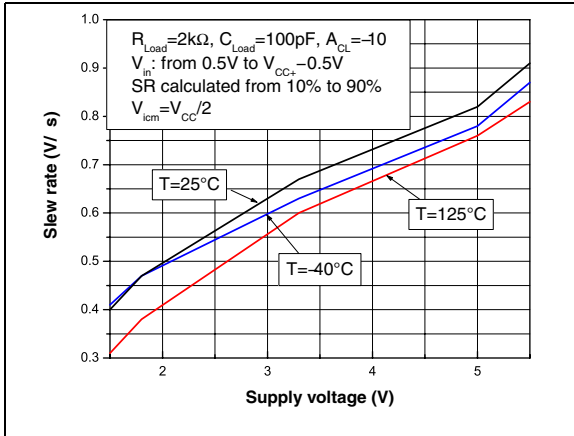


Figure 8. Negative slew rate vs. supply voltage

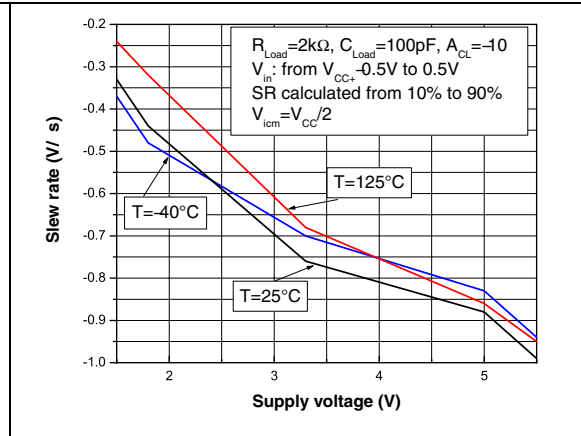


Figure 9. Distortion + noise vs. output voltage at V_{CC} = 1.8 V

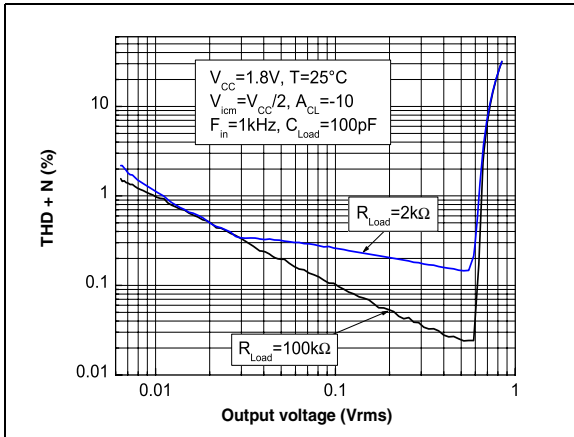


Figure 10. Distortion + noise vs. output voltage at V_{CC} = 5 V

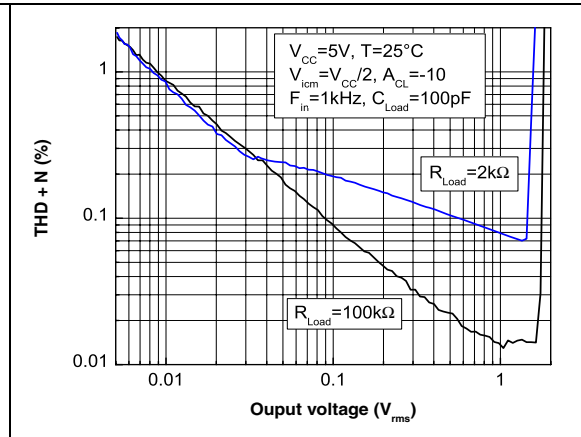


Figure 11. Slew rate timing

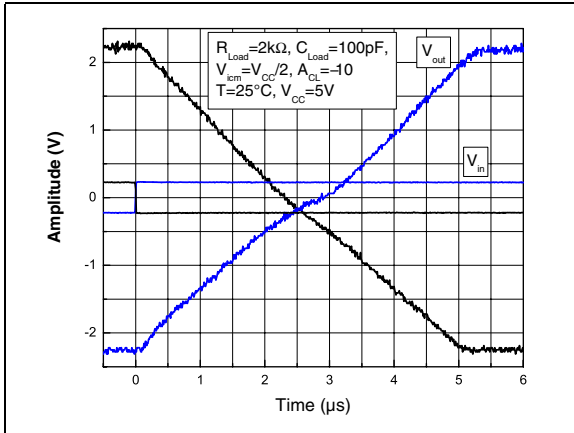
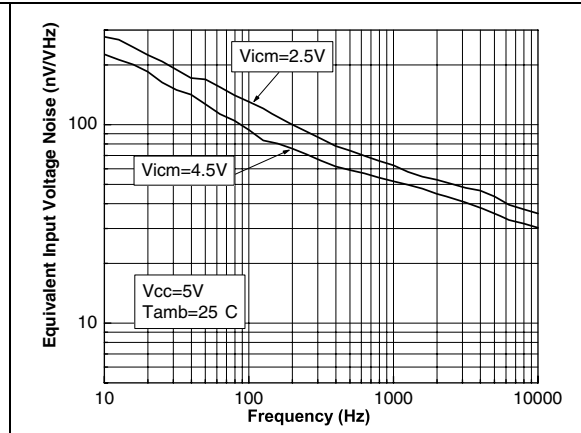


Figure 12. Noise vs. frequency at V_{CC} = 5 V



3 Application information

3.1 Operating voltages

The TSV6390 and TSV6391 can operate from 1.5 to 5.5 V. Their parameters are fully specified for 1.8, 3.3 and 5 V power supplies. However, the parameters are very stable in the full V_{CC} range and several characterization curves show the TSV639x characteristics at 1.5 V. Additionally, the main specifications are guaranteed in extended temperature ranges from -40°C to $+125^{\circ}\text{C}$.

3.2 Rail-to-rail input

The TSV6390 and TSV6391 are built with two complementary PMOS and NMOS input differential pairs. The devices have a rail-to-rail input, and the input common mode range is extended from $V_{CC-} - 0.1\text{ V}$ to $V_{CC+} + 0.1\text{ V}$. The transition between the two pairs appears at $V_{CC+} - 0.7\text{ V}$. In the transition region, the performance of CMRR, PSRR, V_{io} and THD is slightly degraded (as shown in [Figure 13](#) and [Figure 14](#) for V_{io} vs. V_{icm}).

Figure 13. Input offset voltage vs input common mode at $V_{CC} = 1.5\text{ V}$

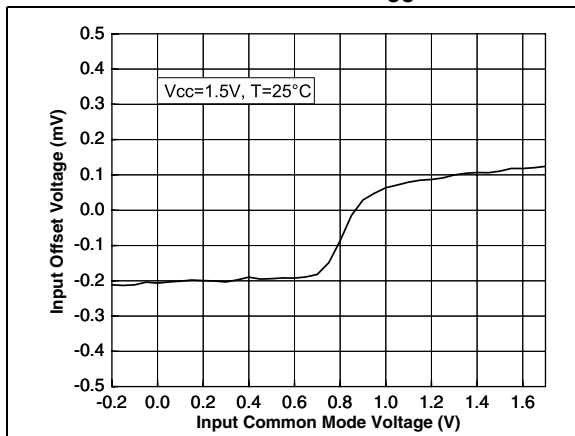
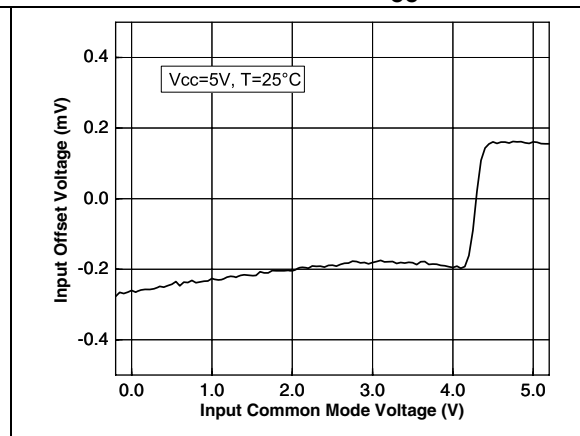


Figure 14. Input offset voltage vs input common mode at $V_{CC} = 5\text{ V}$



The devices are guaranteed without phase reversal.

3.3 Rail-to-rail output

The operational amplifiers' output levels can go close to the rails: 35 mV maximum above and below the rail when connected to a 10 k Ω resistive load to $V_{CC}/2$.

3.4 Shutdown function (TSV6390)

The operational amplifier is enabled when the $\overline{\text{SHDN}}$ pin is pulled high. To disable the amplifier, the $\overline{\text{SHDN}}$ must be pulled down to V_{CC-} . When in shutdown mode, the amplifier's output is in a high impedance state. The $\overline{\text{SHDN}}$ pin must never be left floating, but tied to V_{CC+} or V_{CC-} .

The turn-on and turn-off times are calculated for an output variation of ± 200 mV (Figure 15 and Figure 16 show the test configurations).

Figure 15. Test configuration for turn-on time (Vout pulled down)

Figure 16. Test configuration for turn-off time (Vout pulled down)

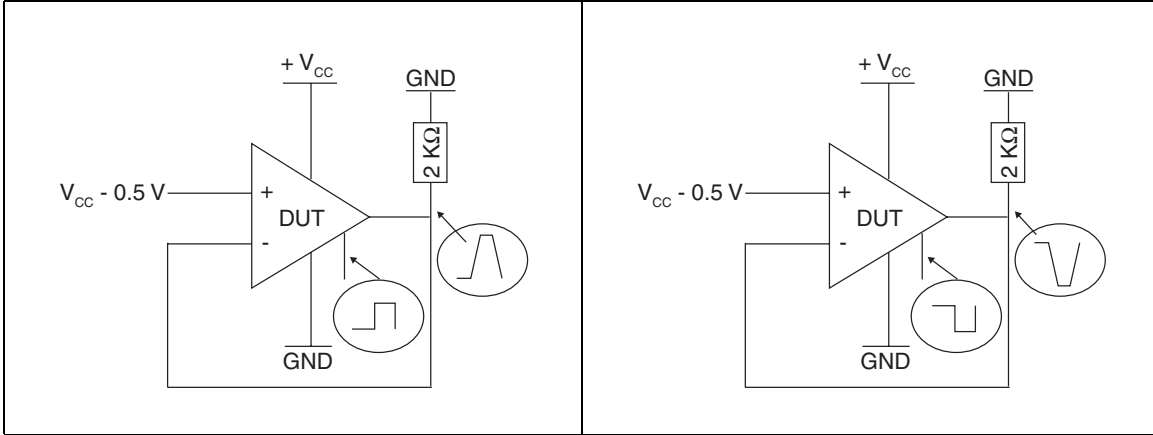
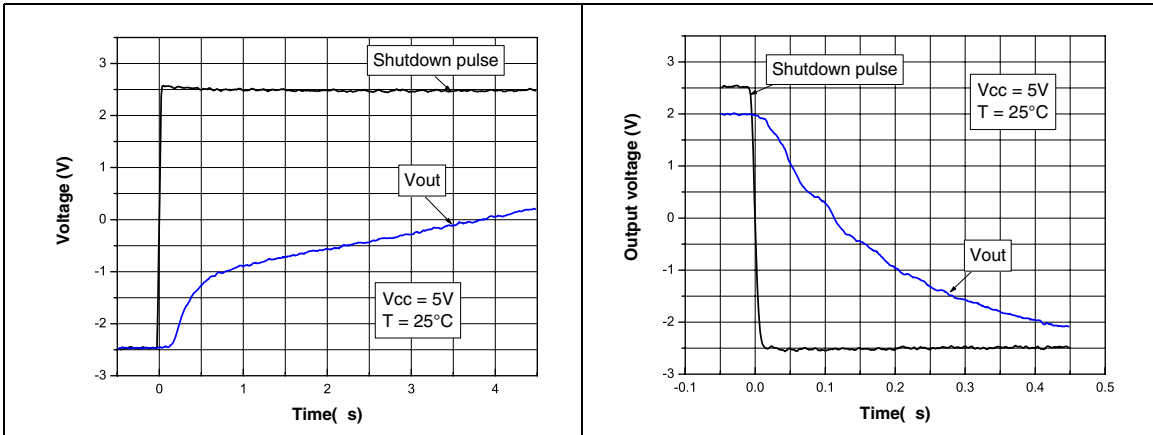


Figure 17. Turn-on time, $V_{CC} = 5$ V, Vout pulled down, $T = 25^\circ$ C

Figure 18. Turn-off time, $V_{CC} = 5$ V, Vout pulled down, $T = 25^\circ$ C



3.5 Optimization of DC and AC parameters

These devices use an innovative approach to reduce the spread of the main DC and AC parameters. An internal adjustment achieves a very narrow spread of the current consumption (60 μA typical, min/max at $\pm 17\%$). Parameters linked to the current consumption value, such as GBP, SR and A_{Vd} , benefit from this narrow dispersion.

3.6 Driving resistive and capacitive loads

These products are micropower, low-voltage operational amplifiers optimized to drive rather large resistive loads, above 2 k Ω . For lower resistive loads, the THD level may significantly increase.

These operational amplifiers have a relatively low internal compensation capacitor, making them very fast while consuming very little. They are ideal when used in a non-inverting configuration or in an inverting configuration in the following conditions.

- $|G_{\text{gain}}| \geq 3$ in an inverting configuration ($C_L = 20 \text{ pF}$, $R_L = 100 \text{ k}\Omega$) or $|G_{\text{gain}}| \geq 10$ ($C_L = 100 \text{ pF}$, $R_L = 100 \text{ k}\Omega$)
- $\text{Gain} \geq +4$ in a non-inverting configuration ($C_L = 20 \text{ pF}$, $R_L = 100 \text{ k}\Omega$) or $\text{gain} \geq +11$ ($C_L = 100 \text{ pF}$, $R_L = 100 \text{ k}\Omega$)

As these operational amplifiers are not unity gain stable, for a low closed-loop gain it is recommended to use the TSV62x (29 μA , 420 kHz) or TSV63x (60 μA , 880 kHz) which are unity gain stable.

Table 8. Related products

| Part # | I _{cc} (μA) at 5 V | GBP (MHz) | SR (V/ μs) | Minimum gain for stability ($C_{\text{Load}} = 100 \text{ pF}$) |
|-----------|--|-----------|------------------------|--|
| TSV620-1 | 29 | 0.42 | 0.14 | 1 |
| TSV6290-1 | 29 | 1.3 | 0.5 | +11 |
| TSV630-1 | 60 | 0.88 | 0.34 | 1 |
| TSV6390-1 | 60 | 2.4 | 1.1 | +11 |

3.7 PCB layouts

For correct operation, it is advised to add 10 nF decoupling capacitors as close as possible to the power supply pins.

3.8 Macromodel

An accurate macromodel of the TSV6390 and TSV6391 is available on STMicroelectronics' web site at www.st.com. This model is a trade-off between accuracy and complexity (that is, time simulation) of the TSV639x operational amplifiers. It emulates the nominal performances of a typical device within the specified operating conditions mentioned in the datasheet. It also helps to validate a design approach and to select the right operational amplifier, *but it does not replace on-board measurements*.

4 Package information

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

4.1 SOT23-5 package mechanical data

Figure 19. SOT23-5L package mechanical drawing

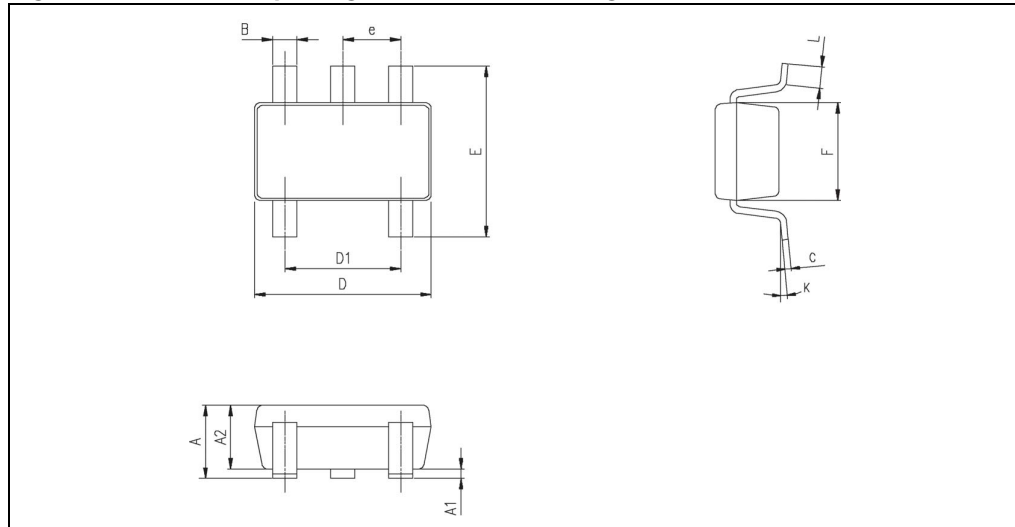


Table 9. SOT23-5L package mechanical data

| 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° | | 10° | | | |

4.2 SOT23-6 package mechanical data

Figure 20. SOT23-6L package mechanical drawing

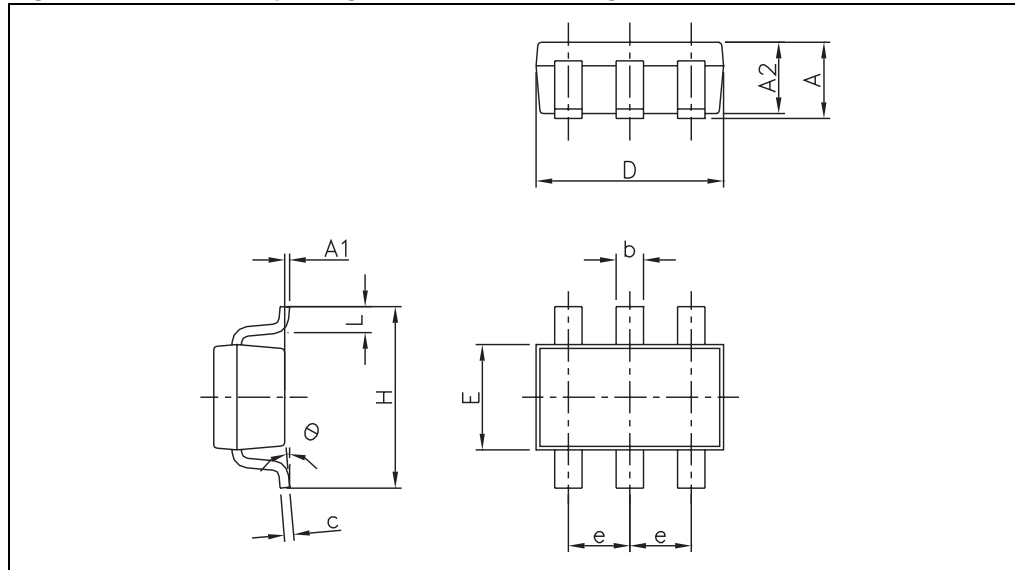


Table 10. SOT23-6L package mechanical data

| Ref. | Dimensions | | | | | |
|------|-------------|------|------|--------|-------|-------|
| | Millimeters | | | Inches | | |
| | Min. | Typ. | Max. | Min. | Typ. | Max. |
| A | 0.90 | | 1.45 | 0.035 | | 0.057 |
| A1 | | | 0.10 | | | 0.004 |
| A2 | 0.90 | | 1.30 | 0.035 | | 0.051 |
| b | 0.35 | | 0.50 | 0.013 | | 0.019 |
| c | 0.09 | | 0.20 | 0.003 | | 0.008 |
| D | 2.80 | | 3.05 | 0.110 | | 0.120 |
| E | 1.50 | | 1.75 | 0.060 | | 0.069 |
| e | | 0.95 | | | 0.037 | |
| H | 2.60 | | 3.00 | 0.102 | | 0.118 |
| L | 0.10 | | 0.60 | 0.004 | | 0.024 |
| ° | 0 | | 10° | | | |

4.3 SC70-5 (or SOT323-5) package mechanical data

Figure 21. SC70-5 (or SOT323-5) package mechanical drawing

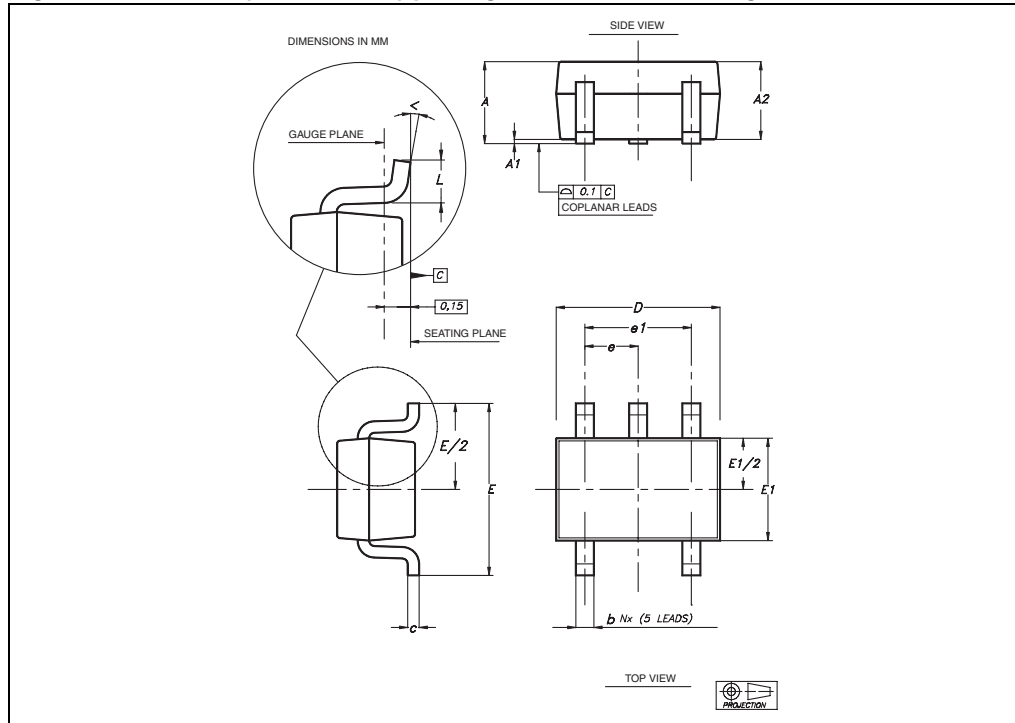


Table 11. SC70-5 (or SOT323-5) package mechanical data

| Ref | Dimensions | | | | | |
|-----|-------------|------|------|--------|-------|-------|
| | Millimeters | | | Inches | | |
| | Min | Typ | Max | Min | Typ | Max |
| A | 0.80 | | 1.10 | 0.315 | | 0.043 |
| A1 | | | 0.10 | | | 0.004 |
| A2 | 0.80 | 0.90 | 1.00 | 0.315 | 0.035 | 0.039 |
| b | 0.15 | | 0.30 | 0.006 | | 0.012 |
| c | 0.10 | | 0.22 | 0.004 | | 0.009 |
| D | 1.80 | 2.00 | 2.20 | 0.071 | 0.079 | 0.087 |
| E | 1.80 | 2.10 | 2.40 | 0.071 | 0.083 | 0.094 |
| E1 | 1.15 | 1.25 | 1.35 | 0.045 | 0.049 | 0.053 |
| e | | 0.65 | | | 0.025 | |
| e1 | | 1.30 | | | 0.051 | |
| L | 0.26 | 0.36 | 0.46 | 0.010 | 0.014 | 0.018 |
| < | 0° | | 8° | | | |

4.4 SC70-6 (or SOT323-6) package mechanical data

Figure 22. SC70-6 (or SOT323-6) package mechanical drawing

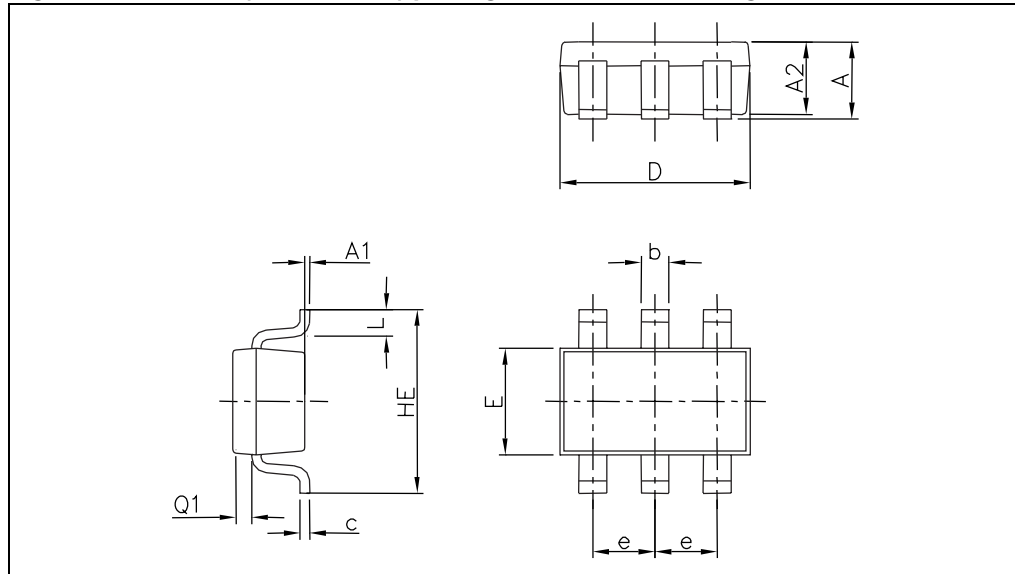
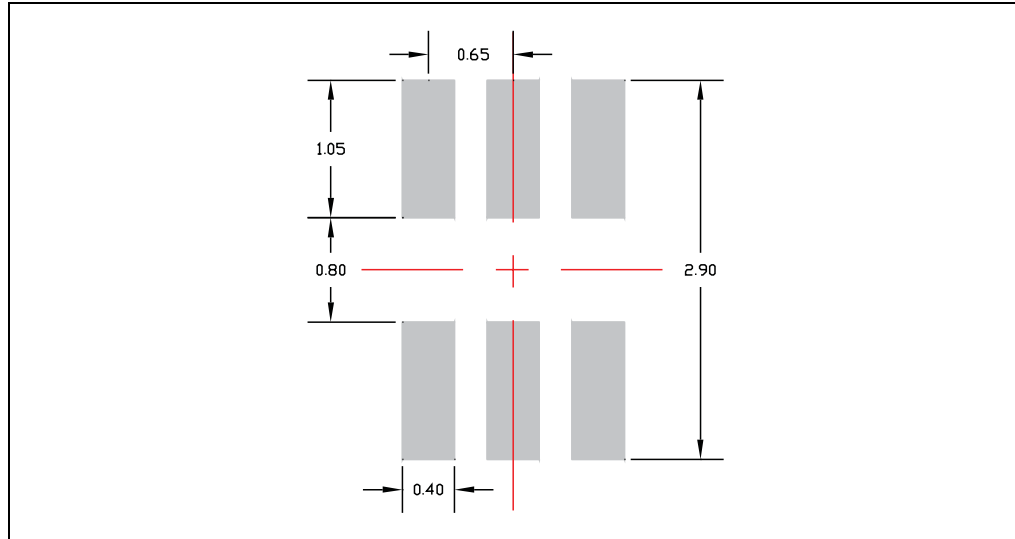


Table 12. SC70-6 (or SOT323-6) package mechanical data

| Ref | Dimensions | | | | | |
|-----|-------------|------|------|--------|-------|-------|
| | Millimeters | | | Inches | | |
| | Min. | Typ. | Max. | Min. | Typ. | Max. |
| A | 0.80 | | 1.10 | 0.031 | | 0.043 |
| A1 | | | 0.10 | | | 0.004 |
| A2 | 0.80 | | 1.00 | 0.031 | | 0.039 |
| b | 0.15 | | 0.30 | 0.006 | | 0.012 |
| c | 0.10 | | 0.18 | 0.004 | | 0.007 |
| D | 1.80 | | 2.20 | 0.071 | | 0.086 |
| E | 1.15 | | 1.35 | 0.045 | | 0.053 |
| e | | 0.65 | | | 0.026 | |
| HE | 1.80 | | 2.40 | 0.071 | | 0.094 |
| L | 0.10 | | 0.40 | 0.004 | | 0.016 |
| Q1 | 0.10 | | 0.40 | 0.004 | | 0.016 |

Figure 23. SC70-6 (or SOT323-6) package footprint



5 Ordering information

Table 13. Order codes

| Part number | Temperature range | Package | Packing | Marking |
|-------------|-------------------|---------|-------------|---------|
| TSV6390ILT | -40°C to +125°C | SOT23-6 | Tape & reel | K109 |
| TSV6390ICT | | SC70-6 | | K19 |
| TSV6390AILT | | SOT23-6 | | K142 |
| TSV6390AICT | | SC70-6 | | K42 |
| TSV6391ILT | | SOT23-5 | | K108 |
| TSV6391ICT | | SC70-5 | | K20 |
| TSV6391AILT | | SOT23-5 | | K141 |
| TSV6391AICT | | SC70-5 | | K41 |

6 Revision history

Table 14. Document revision history

| Date | Revision | Changes |
|-------------|----------|------------------|
| 09-Mar-2010 | 1 | Initial release. |

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