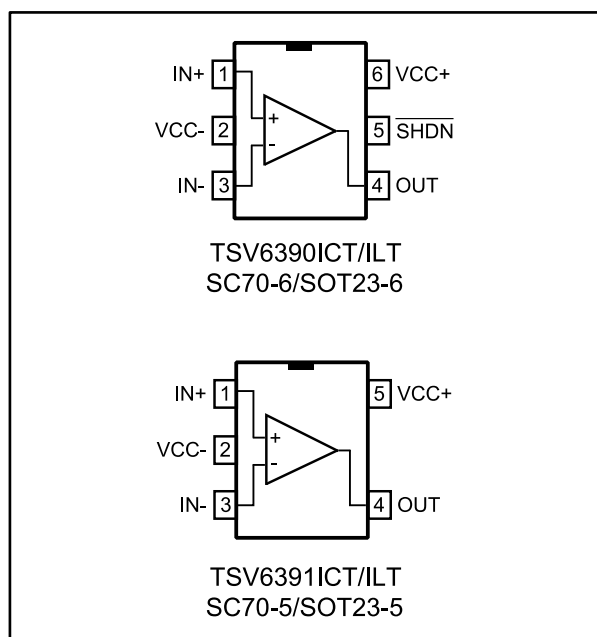


## Micropower (60 $\mu$ A), wide bandwidth (2.4 MHz) CMOS operational amplifiers

Datasheet - production data



- Signal conditioning
- Active filtering
- Medical instrumentation

### Description

The TSV6390, TSV6391, and their "A" versions are single operational amplifiers (op amps) 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  $\mu$ 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  $\mu$ 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.

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  $^{\circ}$ C to 125  $^{\circ}$ C.

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

### Features

- Low offset voltage: 500  $\mu$ V max (A version)
- Low power consumption: 60  $\mu$ 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  $^{\circ}$ C to 125  $^{\circ}$ C
- 4 kV human body model

### Applications

- Battery-powered applications
- Portable devices

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# 1 Absolute maximum ratings and operating conditions

Table 1: Absolute maximum ratings (AMR)

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

**Notes:**

- <sup>(1)</sup>All voltage values, except the differential voltage, are with respect to network ground terminal.
- <sup>(2)</sup>The differential voltage is the non-inverting input terminal with respect to the inverting input terminal.
- <sup>(3)</sup>V<sub>CC-</sub> - V<sub>in</sub> must not exceed 6 V, V<sub>in</sub> must not exceed 6 V.
- <sup>(4)</sup>Input current must be limited by a resistor in series with the inputs.
- <sup>(5)</sup>R<sub>th</sub> are typical values.
- <sup>(6)</sup>Short-circuits can cause excessive heating and destructive dissipation.
- <sup>(7)</sup>Human body model: 100 pF discharged through a 1.5 kΩ resistor between two pins of the device, done for all couples of pin combinations with other pins floating.
- <sup>(8)</sup>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.
- <sup>(9)</sup>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 <sub>CC</sub>	Supply voltage	1.5 to 5.5	V
V <sub>icm</sub>	Common mode input voltage range	(V <sub>CC-</sub> ) - 0.1 to (V <sub>CC+</sub> ) + 0.1	
T <sub>oper</sub>	Operating free air temperature range	-40 to 125	°C

## 2 Electrical characteristics

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

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
<b>DC performance</b>						
$V_{io}$	Offset voltage	TSV6390 and TSV6391			3	mV
		TSV6390A and TSV6391A			0.5	
		$T_{min} < T_{op} < T_{max}$ , TSV6390 and TSV6391			4.5	
		$T_{min} < T_{op} < T_{max}$ , TSV6390A and TSV6391A			2	
$\Delta V_{io}/\Delta T$	Input offset voltage drift			2		$\mu\text{V}/\text{°C}$
$I_{io}$	Input offset current, $V_{out} = V_{CC}/2$ <sup>(1)</sup>			1	10	pA
		$T_{min} < T_{op} < T_{max}$			1	
$I_{ib}$	Input bias current, ( $V_{out} = V_{CC}/2$ ) <sup>(1)</sup>			1	10	pA
		$T_{min} < T_{op} < T_{max}$			1	
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	$R_L = 10\text{ k}\Omega$		5	35	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		
		$T_{min} < T_{op} < T_{max}$	4			
$I_{CC}$	Supply current, $\overline{SHDN} = V_{CC}$	No load, $V_{out} = V_{CC}/2$	40	50	60	$\mu\text{A}$
		$T_{min} < T_{op} < T_{max}$			62	
<b>AC performance</b>						
GBP	Gain bandwidth product	$R_L = 10\text{ k}\Omega$ , $C_L = 100\text{ pF}$		2		MHz
Gain	Minimum gain for stability	Phase margin = $60^\circ$ , $R_f = 10\text{ k}\Omega$ , $R_L = 10\text{ k}\Omega$ , $C_L = 20\text{ pF}$		4		V/V
				-3		
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/ $\mu\text{s}$
$e_n$	Equivalent input noise voltage	$f = 1\text{ kHz}$		60		nV/ $\sqrt{\text{Hz}}$
		$f = 10\text{ kHz}$		33		

### Notes:

<sup>(1)</sup>Guaranteed by design.

Table 4: Shutdown characteristics VCC = 1.8 V (TSV6390)

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

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

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
<b>DC performance</b>						
$V_{io}$	Offset voltage	TSV6390 and TSV6391			3	mV
		TSV6390A and TSV6391A			0.5	
		$T_{min} < T_{op} < T_{max}$ , TSV6390 and TSV6391			4.5	
		$T_{min} < T_{op} < T_{max}$ , TSV6390A and TSV6391A			2	
$\Delta V_{io}/\Delta T$	Input offset voltage drift			2		$\mu\text{V}/^{\circ}\text{C}$
$I_{io}$	Input offset current <sup>(1)</sup>			1	10	pA
		$T_{min} < T_{op} < T_{max}$		1	100	
$I_{ib}$	Input bias current <sup>(1)</sup>			1	10	
		$T_{min} < T_{op} < T_{max}$		1	100	
CMR	Common mode rejection ratio $20 \log (\Delta V_{ic}/\Delta V_{io})$	$0\text{ V to }3.3\text{ V}$ , $V_{out} = 1.65\text{ V}$	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		
		$T_{min} < T_{op} < T_{max}$	83			
$V_{OH}$	High-level output voltage	$R_L = 10\text{ k}\Omega$		6	35	mV
		$T_{min} < T_{op} < T_{max}$			50	
$V_{OL}$	Low-level output voltage	$R_L = 10\text{ k}\Omega$		7	35	
		$T_{min} < T_{op} < T_{max}$			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		
		$T_{min} < T_{op} < T_{max}$	20			
$I_{CC}$	Supply current, $\overline{\text{SHDN}} = V_{CC}$	No load, $V_{out} = V_{CC}/2$	43	55	64	$\mu\text{A}$
		$T_{min} < T_{op} < T_{max}$			66	
<b>AC performance</b>						
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 = $60^{\circ}$ , $R_f = 10\text{ k}\Omega$ , $R_L = 10\text{ k}\Omega$ , $C_L = 20\text{ pF}$ ,		4		V/V
				-3		
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/ $\mu\text{s}$
$e_n$	Equivalent input noise voltage	$f = 1\text{ kHz}$		65		nV/ $\sqrt{\text{Hz}}$

**Notes:**<sup>(1)</sup>Guaranteed by design.

Table 6: Electrical characteristics at VCC+ = 5 V with VCC- = 0 V, Vicm = VCC/2, Tamb = 25 °C and RL connected to VCC/2 (unless otherwise specified)

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
<b>DC performance</b>						
V <sub>io</sub>	Offset voltage	TSV6390 and TSV6391			3	mV
		TSV6390A and TSV6391A			0.5	
		T <sub>min</sub> < T <sub>op</sub> < T <sub>max</sub> , TSV6390 and TSV6391			4.5	
		T <sub>min</sub> < T <sub>op</sub> < T <sub>max</sub> , TSV6390A and TSV6391A			2	
ΔV <sub>io</sub> /ΔT	Input offset voltage drift			2		μV/°C
I <sub>io</sub>	Input offset current, V <sub>out</sub> = V <sub>CC</sub> /2 <sup>(1)</sup>			1	10	pA
		T <sub>min</sub> < T <sub>op</sub> < T <sub>max</sub>		1	100	
I <sub>ib</sub>	Input bias current, V <sub>out</sub> = V <sub>CC</sub> /2 <sup>(1)</sup>			1	10	pA
		T <sub>min</sub> < T <sub>op</sub> < T <sub>max</sub>		1	100	
CMR	Common mode rejection ratio 20 log (ΔV <sub>ic</sub> /ΔV <sub>io</sub> )	0 V to 5 V, V <sub>out</sub> = 2.5 V	60	80		dB
		T <sub>min</sub> < T <sub>op</sub> < T <sub>max</sub>	55			
SVR	Supply voltage rejection ratio 20 log (ΔV <sub>CC</sub> /ΔV <sub>io</sub> )	V <sub>CC</sub> = 1.8 to 5 V	75	93		dB
		T <sub>min</sub> < T <sub>op</sub> < T <sub>max</sub>	73			
A <sub>vd</sub>	Large signal voltage gain	R <sub>L</sub> = 10 kΩ, V <sub>out</sub> = 0.5 V to 4.5 V	89	98		
		T <sub>min</sub> < T <sub>op</sub> < T <sub>max</sub>	84			
V <sub>OH</sub>	High-level output voltage	R <sub>L</sub> = 10 kΩ		7	35	mV
		T <sub>min</sub> < T <sub>op</sub> < T <sub>max</sub>			50	
V <sub>OL</sub>	Low-level output voltage	R <sub>L</sub> = 10 kΩ		6	35	mV
		T <sub>min</sub> < T <sub>op</sub> < T <sub>max</sub>			50	
I <sub>out</sub>	I <sub>sink</sub>	V <sub>out</sub> = 5 V	40	65		mA
		T <sub>min</sub> < T <sub>op</sub> < T <sub>max</sub>	35			
	I <sub>source</sub>	V <sub>out</sub> = 0 V	40	72		
		T <sub>min</sub> < T <sub>op</sub> < T <sub>max</sub>	35			
I <sub>CC</sub>	Supply current, $\overline{\text{SHDN}} = V_{CC}$	No load, V <sub>out</sub> = V <sub>CC</sub> /2	50	60	69	μA
		T <sub>min</sub> < T <sub>op</sub> < T <sub>max</sub>			72	
<b>AC performance</b>						
GBP	Gain bandwidth product	R <sub>L</sub> = 10 kΩ, C <sub>L</sub> = 100 pF		2.4		MHz
Gain	Minimum gain for stability	Phase margin = 60°, R <sub>f</sub> = 10 kΩ, R <sub>L</sub> = 10 kΩ, C <sub>L</sub> = 20 pF,		4		V/V
				-3		
SR	Slew rate	R <sub>L</sub> = 10 kΩ, C <sub>L</sub> = 100 pF		1.1		V/μs
e <sub>n</sub>	Equivalent input noise voltage	f = 1 kHz		60		nV/√Hz
		f = 10 kHz		33		
THD+N	Total harmonic distortion + noise	A <sub>v</sub> = -10, f <sub>in</sub> = 1 kHz, R = 100 kΩ, V <sub>icm</sub> = V <sub>CC</sub> /2, V <sub>in</sub> = 40 mVpp		0.11		%

**Notes:**

<sup>(1)</sup>Guaranteed by design.

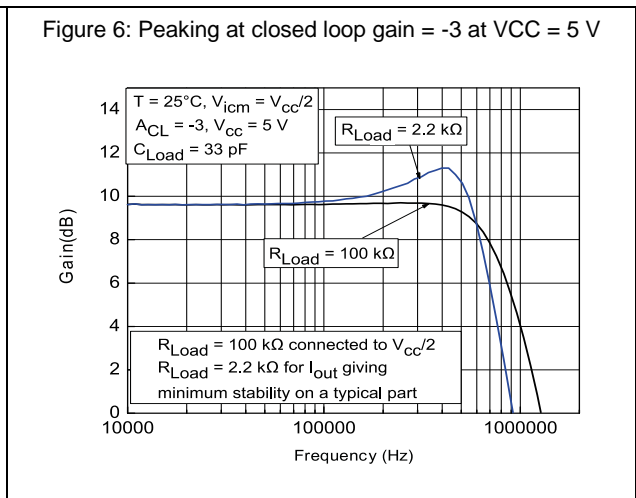
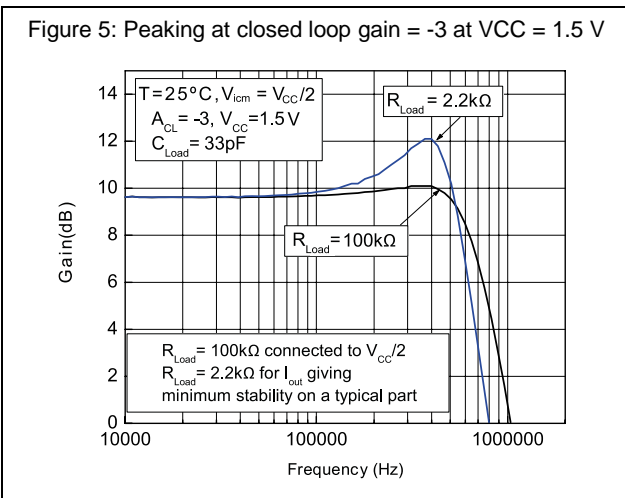
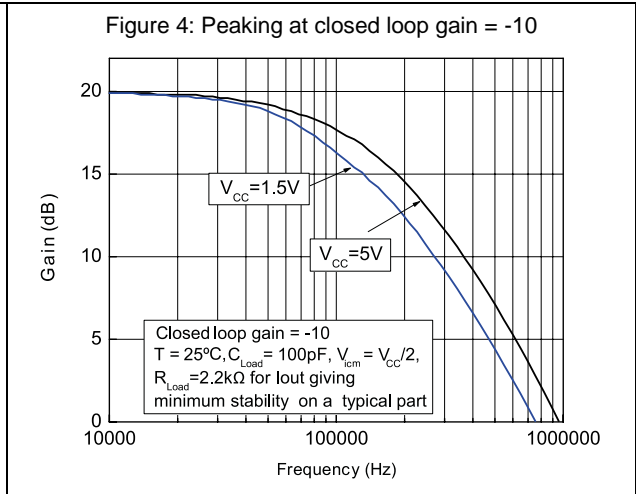
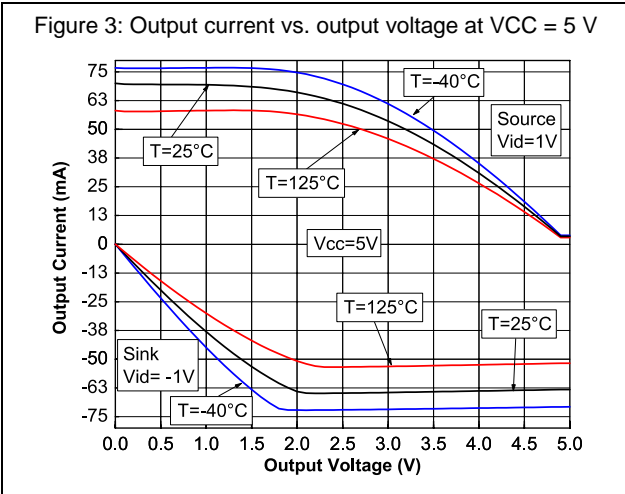
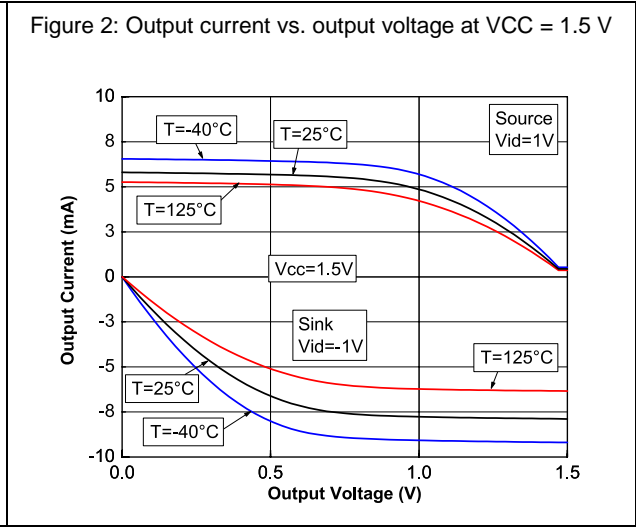
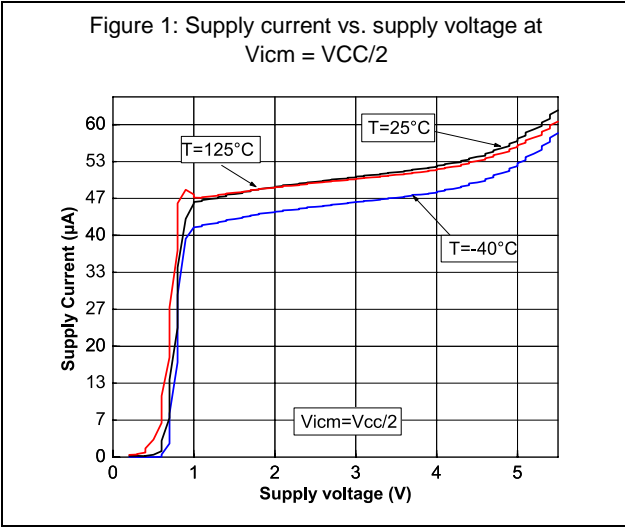


Table 7: Shutdown characteristics VCC = 5 V (TSV6390)

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

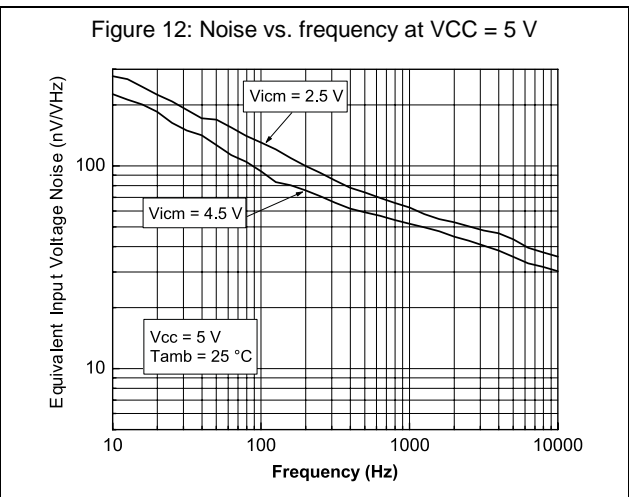
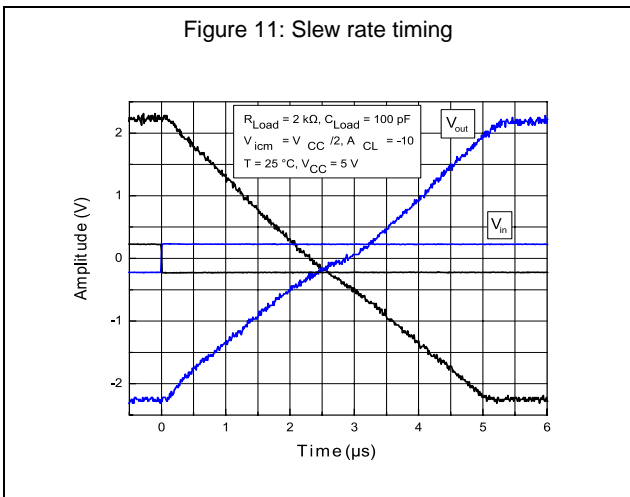
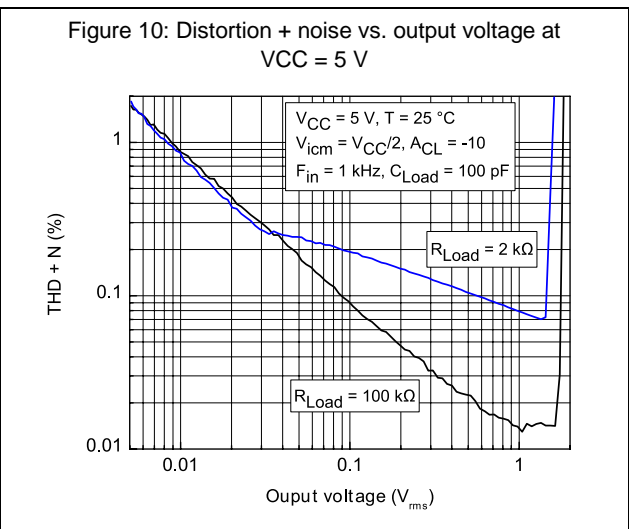
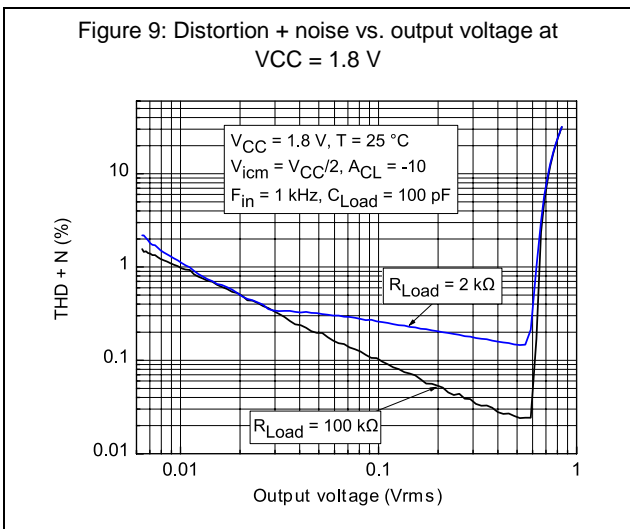
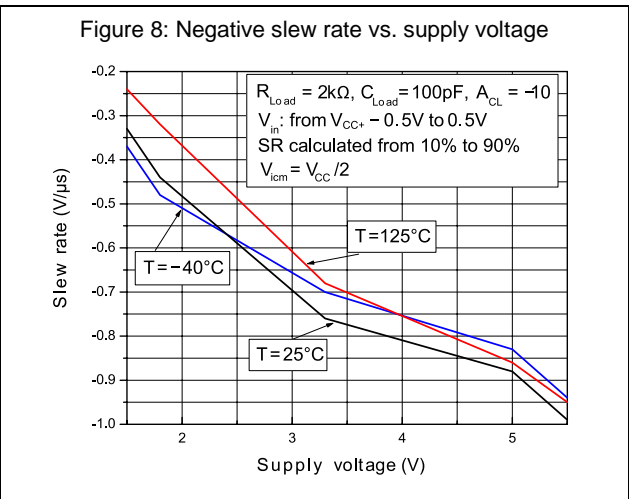
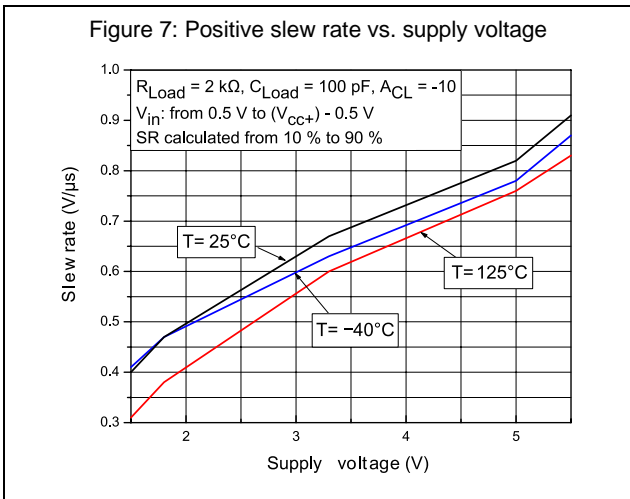


### 3 Electrical characteristics curves



Electrical characteristics curves

TSV6390, TSV6390A, TSV6391, TSV6391A



## 4 Application information

### 4.1 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  $-40\text{ }^{\circ}\text{C}$  to  $125\text{ }^{\circ}\text{C}$ .

### 4.2 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  $V_{CC} = 1.5\text{ V}$

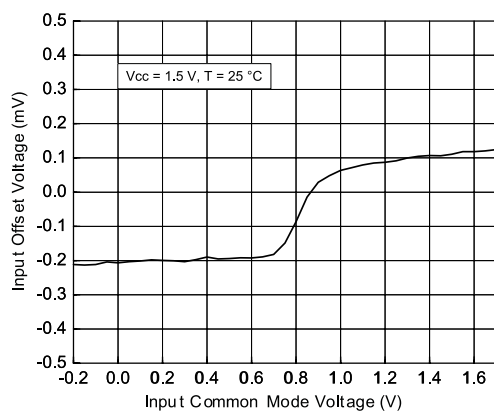
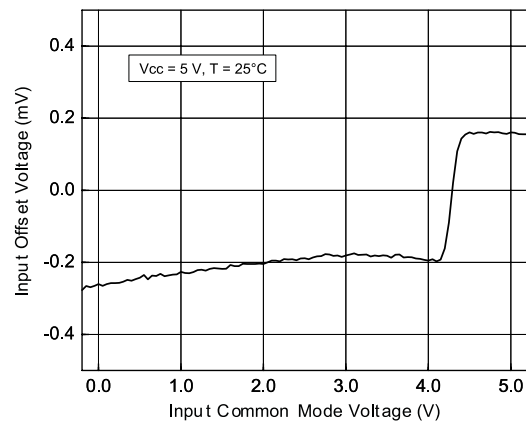


Figure 14: Input offset voltage vs input common-mode at  $V_{CC} = 5\text{ V}$



The devices are guaranteed without phase reversal.

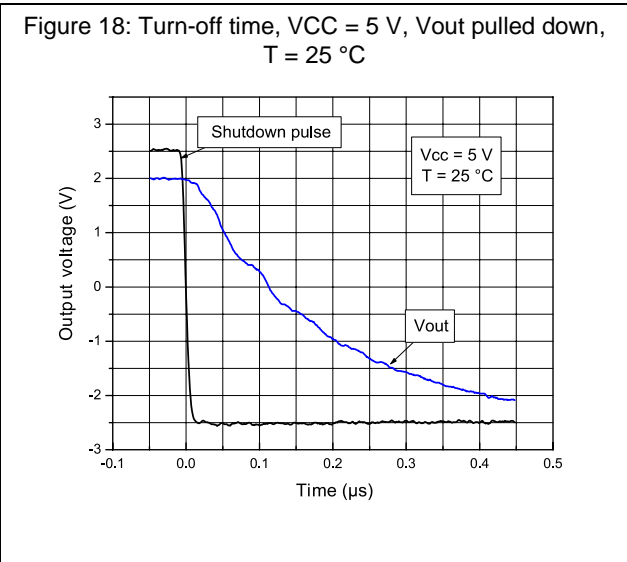
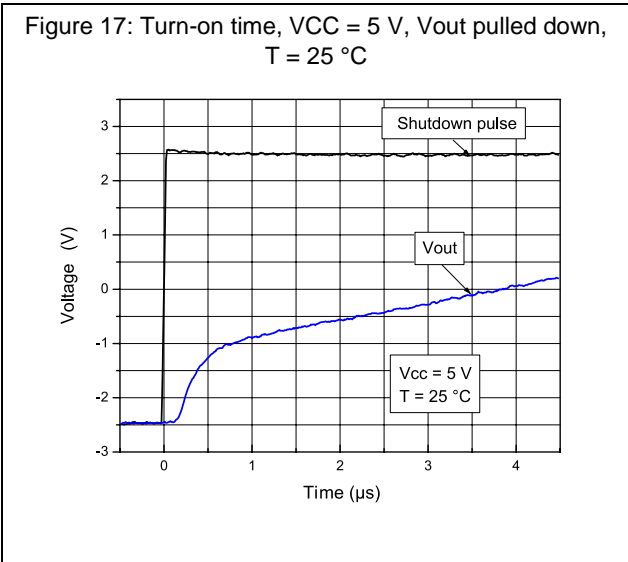
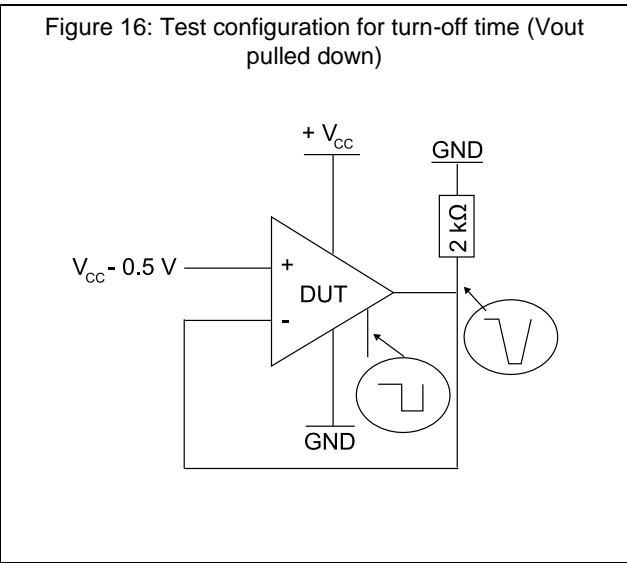
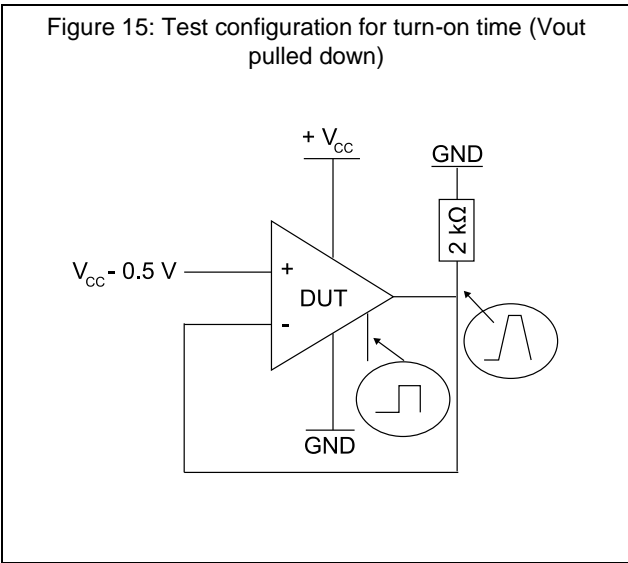
### 4.3 Rail-to-rail output

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

### 4.4 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  $V_{\text{CC-}}$ . 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 kept tied to  $V_{\text{CC+}}$  or  $V_{\text{CC-}}$ .

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



## 4.5 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  $\mu\text{A}$  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.

## 4.6 Driving resistive and capacitive loads

These products are micropower, low-voltage operational amplifiers optimized to drive rather large resistive loads, above 2 k $\Omega$ . 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.

- $|Gain| \geq 3$  in an inverting configuration ( $C_L = 20$  pF,  $R_L = 100$  k $\Omega$ ) or  $|gain| \geq 10$ , ( $C_L = 100$  pF,  $R_L = 100$  k $\Omega$ )
- $Gain \geq 4$  in a non-inverting configuration ( $C_L = 20$  pF,  $R_L = 100$  k $\Omega$ ) or  $gain \geq 11$ , ( $C_L = 100$  pF,  $R_L = 100$  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  $\mu\text{A}$ , 420 kHz) or TSV63x (60  $\mu\text{A}$ , 880 kHz) which are unity gain stable.

Table 8: Related products

Part #	I <sub>cc</sub> ( $\mu\text{A}$ ) at 5 V	GBP (MHz)	SR (V/ $\mu\text{s}$ )	Minimum gain for stability ( $C_{Load} = 100$ 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

## 4.7 PCB layouts

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

## 4.8 Macromodel

An accurate macromodel of the TSV6390 and TSV6391 is available on STMicroelectronics' web site at: [www.st.com](http://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*.

## 5 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.

### 5.1 SC70-6 (or SOT323-6) package information

Figure 19: SC70-6 (or SOT323-6) package outline

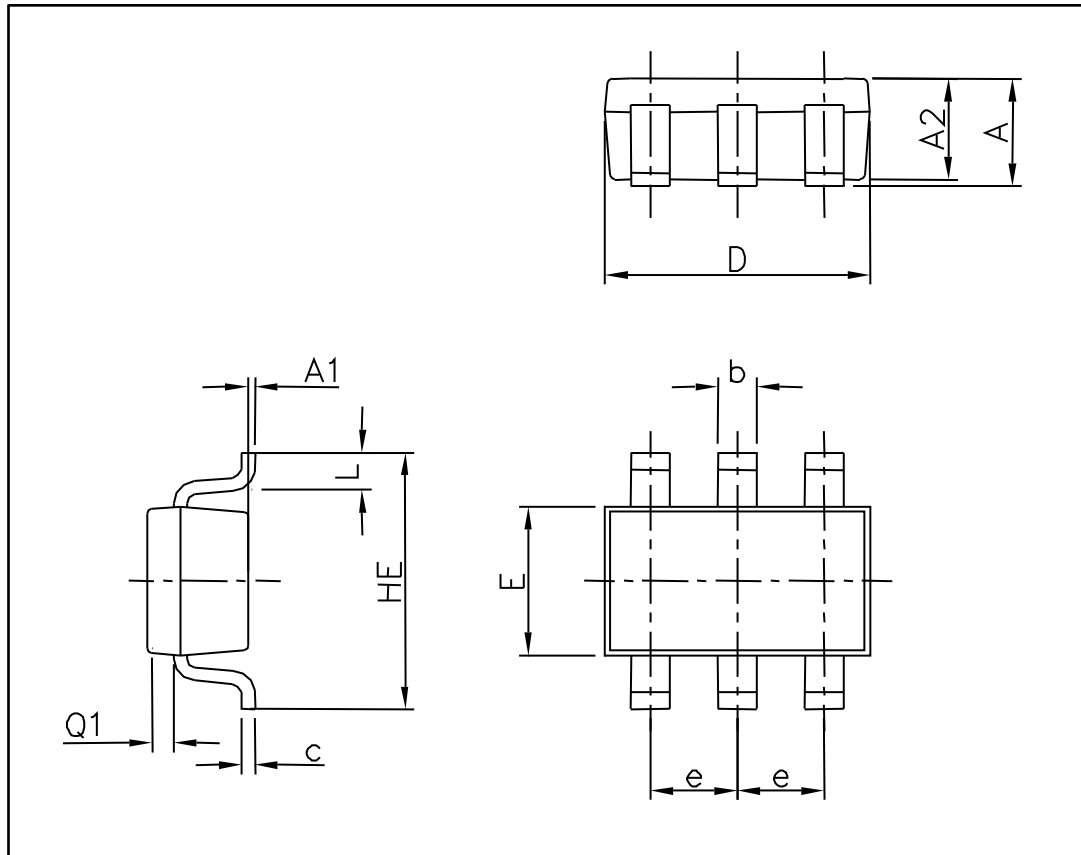
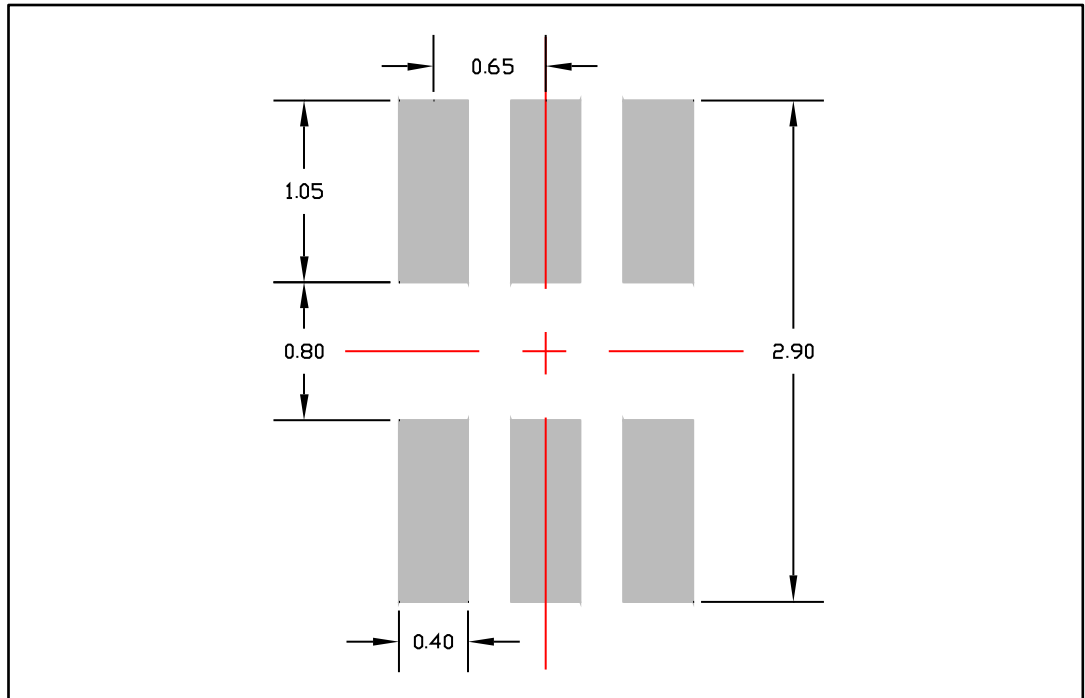


Table 9: SC70-6 (or SOT323-6) mechanical data

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 20: SC70-6 (or SOT323-6) recommended footprint





## 5.2 SOT23-6 package information

Figure 21: SOT23-6 package outline

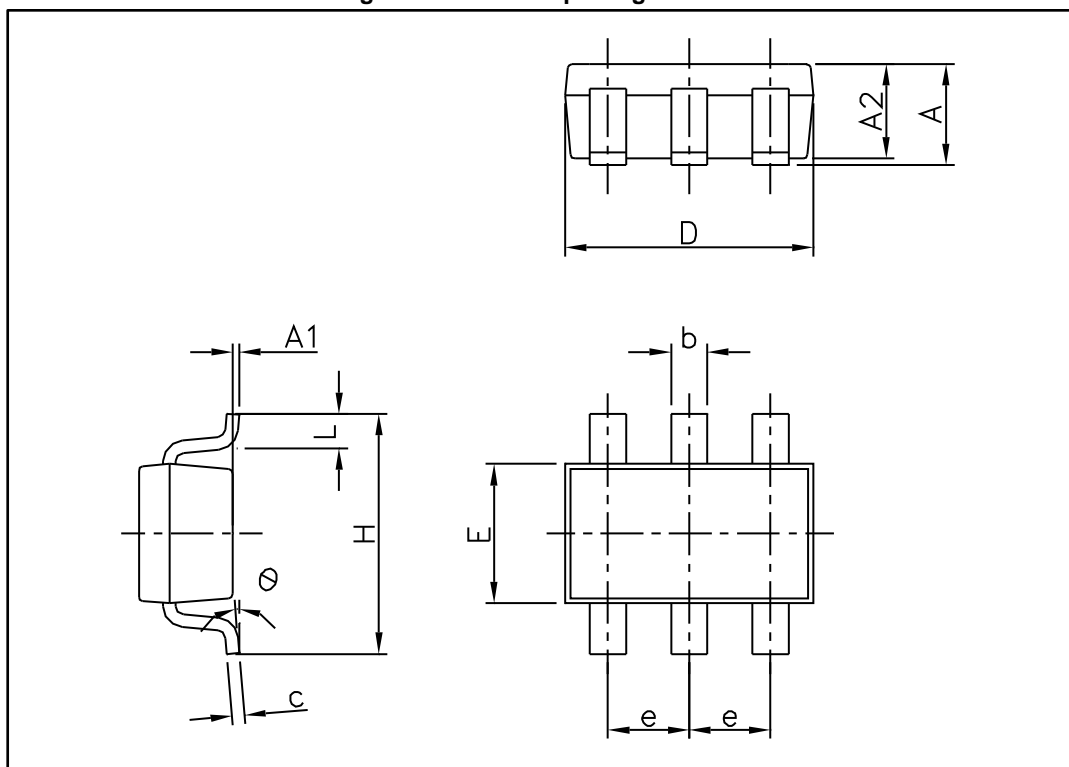


Table 10: SOT23-6 mechanical data

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
θ	0°		10°	0°		10°

### 5.3 SC70-5 (or SOT323-5) package information

Figure 22: SC70-5 (or SOT323-5) package outline

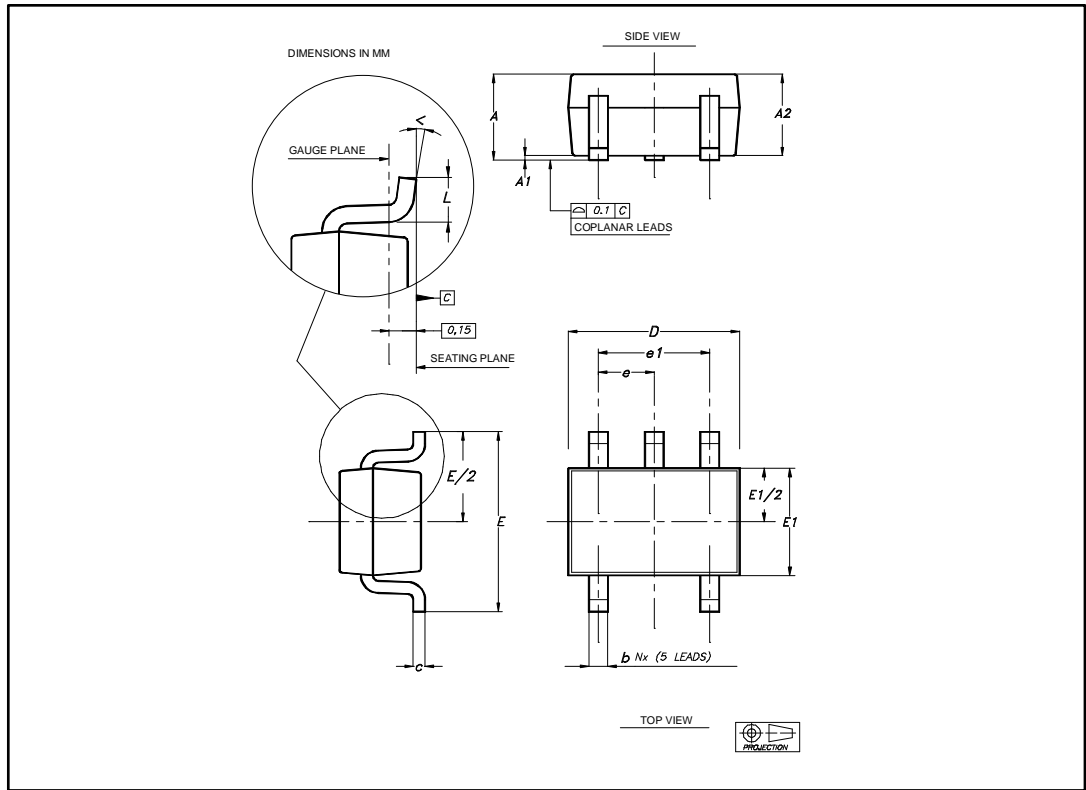


Table 11: SC70-5 (or SOT323-5) mechanical data

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°	0°		8°

### 5.4 SOT23-5 package information

Figure 23: SOT23-5 package outline

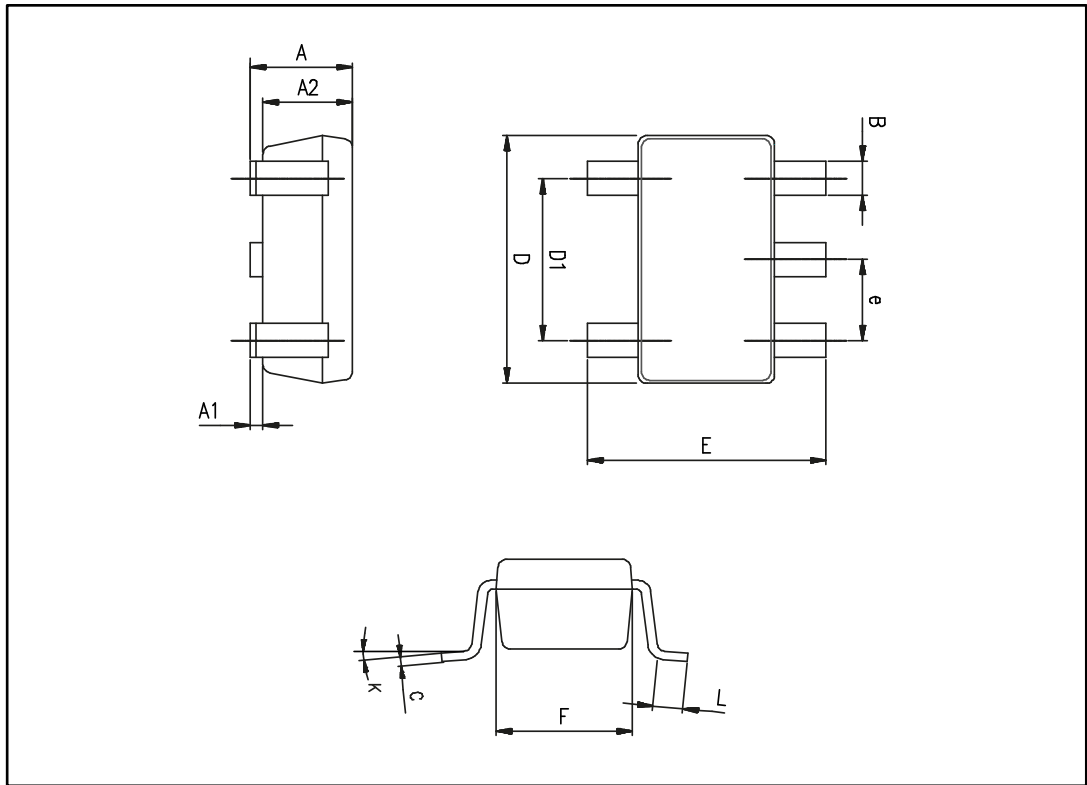


Table 12: SOT23-5 mechanical data

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	0.014	0.016	0.020
C	0.09	0.15	0.20	0.004	0.006	0.008
D	2.80	2.90	3.00	0.110	0.114	0.118
D1		1.90			0.075	
e		0.95			0.037	
E	2.60	2.80	3.00	0.102	0.110	0.118
F	1.50	1.60	1.75	0.059	0.063	0.069
L	0.10	0.35	0.60	0.004	0.014	0.024
K	0 degrees		10 degrees	0 degrees		10 degrees

## 6 Ordering information

Table 13: Order codes

Part number	Temperature range	Package	Packing	Marking
TSV6390ILT	-40 °C to 125 °C	SOT23-6	Tape and 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

## 7 Revision history

**Table 14: Document revision history**

Date	Revision	Changes
09-Mar-2010	1	Initial release.
04-Dec-2015	2	Updated layout <i>Section 2: "Electrical characteristics"</i> : replaced $DV_{iO}$ by $\Delta V_{iO}/\Delta T$ and updated $V_{OH}$ values. In <i>Table 7</i> , updated $t_{off}$ conditions. <i>Electrical characteristic curves</i> : updated Y-axes of <i>Figure 7</i> and <i>Figure 8</i> . <i>Shutdown function (TSV6390)</i> : updated X-axes of <i>Figure 17</i> and <i>Figure 18</i> . <i>Table 10</i> : replaced ° with $\theta$