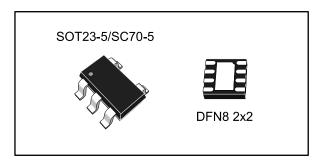


### Rail-to-rail high-speed comparator

Datasheet - production data



### **Features**

- Propagation delay: 8 ns
- Low current consumption: 470 μA typ. at 5 V
- Rail-to-rail inputs
- Push-pull outputs
- Supply operation from 2.2 to 5 V
- Wide temperature range: -40 °C to 125 °C
- ESD tolerance: 2 kV HBM/200 V MM
- Latch-up immunity: 200 mA
- SMD packages
- Automotive qualification

### **Applications**

- Telecoms
- Instrumentation
- Signal conditioning
- High-speed sampling systems
- Portable communication systems

### **Description**

The TS3011 single comparator features a high-speed response time with rail-to-rail inputs. Specified for a supply voltage of 2.2 to 5 V, this comparator can operate over a wide temperature range from -40 °C to 125 °C.

The TS3011 offers micropower consumption as low as a few hundred microamperes, thus providing an excellent ratio of power consumption current versus response time.

The TS3011 includes push-pull outputs and is available in tiny packages to overcome space constraints.

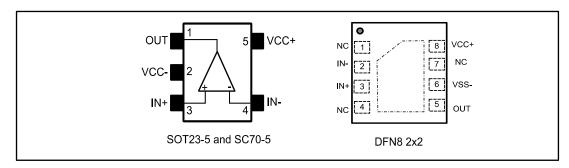
Contents TS3011

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TS3011 Pin configuration

# 1 Pin configuration



### 2 Absolute maximum ratings and operating conditions

Table 1: Absolute maximum ratings

Symbol	Parameter		Value	Unit	
Vcc	Supply voltage (1)	ge <sup>(1)</sup>			
V <sub>ID</sub>	Differential input voltage (2)		±5	V	
V <sub>IN</sub>	Input voltage range		$(V_{CC}^{-})$ - 0.3 to $(V_{CC}^{+})$ + 0.3		
D	Thermal resistance junction-to-ambient (3)	SOT23-5	250		
Rтнja	Thermal resistance junction-to-ambient	SC70-5	205	°C/W	
D	Thermal registeres junction to cook (3)	SOT23-5	81	C/VV	
Rтн <sub>ј</sub> с	Thermal resistance junction-to-case (3)	SC70-5	172		
T <sub>STG</sub>	Storage temperature		-65 to 150		
TJ	Junction temperature		150	°C	
T <sub>LEAD</sub>	Lead temperature (soldering 10 seconds)		260		
	Human body model (HBM) (4)	2000			
ECD.	Machine model (MM) (5)		200	W	
ESD	Charged device model (CDM) (6)	SOT23-5	1500	V	
	Charged device model (CDM) <sup>(6)</sup>	SC70-5	1300		
	Latch-up immunity		200	mA	

**Table 2: Operating conditions** 

Symbol	Parameter	Value	Unit
Toper	Operating temperature range	-40 to 125	°C
Vcc	Supply voltage (Vcc+ - Vcc-), -40 °C < T <sub>amb</sub> < 125 °C	2.2 to 5	
VICM	Common mode input voltage range, -40 °C < T <sub>amb</sub> < 125 °C	(Vcc <sup>-</sup> ) - 0.2 to (Vcc <sup>+</sup> ) + 0.2	V



 $<sup>\</sup>ensuremath{^{(1)}}\mbox{All}$  voltage values, except the differential voltage, are referenced to  $\ensuremath{^{Vcc^{\text{-}}}}\mbox{.}$ 

<sup>(2)</sup> The magnitude of input and output voltages must never exceed the supply rail ±0.3 V.

<sup>&</sup>lt;sup>(3)</sup>Short-circuits can cause excessive heating. These values are typical.

<sup>&</sup>lt;sup>(4)</sup>Human body model: a 100 pF capacitor is charged to the specified voltage, then discharged through a 1.5 kΩ resistor between two pins of the device. This is done for all couples of connected pin combinations while the other pins are floating.

 $<sup>^{(5)}</sup>$ 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  $\Omega$ ). This is done for all couples of connected pin combinations while the other pins are floating.

<sup>&</sup>lt;sup>(6)</sup>Charged device model: all pins and package are charged together to the specified voltage and then discharged directly to ground.

### 3 Electrical characteristics

In the electrical characteristic tables below, all values over the temperature range are guaranteed through correlation and simulation. No production tests are performed at the temperature range limits.

Table 3: VCC = 2.2 V, VICM = VCC/2, T<sub>amb</sub> = 25 °C (unless otherwise specified)

Symbol	Parameter	Test conditions	Min.	Тур.	Max.	Unit
\/	Input offset voltage (1)		-7	-0.2	7	m)/
Vio	Input offset voltage (1)	-40 °C < T <sub>amb</sub> < 125 °C	-8		8	mV
$\Delta V_{IO}$	Input offset voltage drift	-40 °C < T <sub>amb</sub> < 125 °C		5	20	μV/°C
V <sub>HYST</sub>	Input hysteresis voltage (2)			2		mV
lio	Input offset current (3)			1	20	
IIO	input onset current	-40 °C < T <sub>amb</sub> < 125 °C			100	рА
I <sub>IB</sub>	Input bias current			1	20	PΛ
IID	input bias current	-40 °C < T <sub>amb</sub> < 125 °C			100	
		No load, output high		0.52	0.64	
laa	Supply current	No load, output high, -40 °C < T <sub>amb</sub> < 125 °C			0.9	
I <sub>CC</sub>	Зарріу сапені	No load, output low		0.65	0.88	mΛ
		No load, output low, -40 °C < T <sub>amb</sub> < 125 °C			1.1 mA	
ı	Chart singuit surrent	Source	14	18		
Isc	Short circuit current	Sink	11	14		
V	Output voltage high	I <sub>source</sub> = 4 mA	1.94	4 1.97		V
V <sub>OH</sub>	Output voltage night	-40 °C < T <sub>amb</sub> < 125 °C	1.85			V
Vol	Output voltage low	I <sub>sink</sub> = 4 mA		150	190	mV
VOL	Output voltage low	-40 °C < T <sub>amb</sub> < 125 °C			250	111 V
CMRR	Common-mode rejection ratio	0 < V <sub>ICM</sub> < 2.7 V	50	68		dB
		$C_L = 12$ pF, $R_L = 1$ M $\Omega$ , overdrive = 5 mV		16		
$T_PLH$	Propagation delay, low to high output level (4)	$C_L = 12 \text{ pF}, R_L = 1 \text{ M}\Omega,$ overdrive = 15 mV		12		
		$C_L = 12 \text{ pF}, R_L = 1 \text{ M}\Omega,$ overdrive = 50 mV		10	15	
		$\begin{split} C_L = 12 \text{ pF, } R_L = 1 \text{ M}\Omega, \\ \text{overdrive} = 5 \text{ mV} \end{split}$		16		
T <sub>PHL</sub>	Propagation delay, high to low output level (5)	$C_L = 12 \text{ pF}, R_L = 1 \text{ M}\Omega,$ overdrive = 15 mV		12		ns
		$C_L = 12 \text{ pF}, R_L = 1 \text{ M}\Omega,$ overdrive = 50 mV		10	15	
T <sub>R</sub>	Rise time (10 % to 90 %)	$C_L = 12 \text{ pF}, R_L = 1 \text{ M}\Omega,$ overdrive = 100 mV		3.0		
T <sub>F</sub>	Fall time (90 % to 10 %)	$C_L = 12 \text{ pF}, R_L = 1 \text{ M}\Omega,$ overdrive = 100 mV		2.5		

Table 4: VCC = 2.7 V, VICM = VCC/2, Tamb = 25 °C (unless otherwise specified)

Symbol	Parameter	Test conditions	Min.	Тур.	Max.	Unit	
\/	Input offset voltage (1)		-7	-0.1	7	mV	
V <sub>IO</sub>	Input offset voltage (1)	-40 °C < T <sub>amb</sub> < 125 °C	-9		9	IIIV	
ΔVιο	Input offset voltage drift	-40 °C < T <sub>amb</sub> < 125 °C		5	20	μV/°C	
V <sub>HYST</sub>	Input hysteresis voltage (2)			2		mV	
lio	Input offset current (3)			1	20		
IIO	input onset current 19	-40 °C < T <sub>amb</sub> < 125 °C			100	nΛ	
lin	Input bigs current			1	20	pA	
I <sub>IB</sub>	Input bias current	-40 °C < T <sub>amb</sub> < 125 °C			100		
		No load, output high		0.52	0.65		
,	Cumply augment	No load, output high, -40 °C < T <sub>amb</sub> < 125 °C			0.9		
Icc	Supply current	No load, output low		0.66	0.89	A	
		No load, output low, -40 °C < T <sub>amb</sub> < 125 °C			1.1	mA	
	Object singuity suggests	Source	24	27			
Isc	Short circuit current	Sink	19	22			
V	Output voltage high	I <sub>source</sub> = 4 mA	2.48	2.52		V	
Vон	Output voltage high	-40 °C < T <sub>amb</sub> < 125 °C	2.40			V	
		I <sub>sink</sub> = 4 mA		130	170		
V <sub>OL</sub>	Output voltage low	-40 °C < T <sub>amb</sub> < 125 °C			220	mV	
CMRR	Common-mode rejection ratio	0 < V <sub>ICM</sub> < 2.7 V	52	70		dB	
		$C_L = 12 \text{ pF}, R_L = 1 \text{ M}\Omega,$ overdrive = 5 mV		16		20	
T <sub>PLH</sub>	Propagation delay, low to high output level (4)	$C_L = 12 \text{ pF}, R_L = 1 \text{ M}\Omega,$ overdrive = 15 mV		11		ns	
		$C_L = 12 \text{ pF}, R_L = 1 \text{ M}\Omega,$ overdrive = 50 mV		9	13		
		$C_L = 12 \text{ pF}, R_L = 1 \text{ M}\Omega,$ overdrive = 5 mV		16		ns	
T <sub>PHL</sub>	Propagation delay, high to low output level <sup>(5)</sup>	$C_L = 12 \text{ pF}, R_L = 1 \text{ M}\Omega,$ overdrive = 15 mV		11		115	
		$C_L = 12 \text{ pF}, R_L = 1 \text{ M}\Omega,$ overdrive = 50 mV		9	13		

<sup>&</sup>lt;sup>(1)</sup>The offset is defined as the average value of positive (V<sub>TRIP+</sub>) and negative (V<sub>TRIP-</sub>) trip points (input voltage differences) requested to change the output state in each direction.

<sup>(2)</sup> Hysteresis is a built-in feature of the TS3011. It is defined as the voltage difference between the trip points.

 $<sup>^{(3)}</sup>$ Maximum values include unavoidable inaccuracies of the industrial tests.

 $<sup>^{(4)}</sup>$ Overdrive is measured with reference to the  $V_{TRIP+}$  point.

 $<sup>^{(5)}</sup>$ Overdrive is measured with reference to the V<sub>TRIP-</sub> point.

Symbol	Parameter	Test conditions	Min.	Тур.	Max.	Unit
T <sub>R</sub>	Rise time (10 % to 90 %)	$C_L = 12 \text{ pF}, R_L = 1 \text{ M}\Omega,$ overdrive = 100 mV		2.3		ns
T <sub>F</sub>	Fall time (90 % to 10 %)	$C_L = 12 \text{ pF}, R_L = 1 \text{ M}\Omega,$ overdrive = 100 mV		1.8		0

Table 5: VCC = 5 V, VICM = VCC/2, Tamb = 25 °C (unless otherwise specified)

Symbol	Parameter	Test conditions	Min.	Тур.	Max.	Unit
\/	Input offect voltage (1)		-7	-0.4	7	mV
V <sub>IO</sub>	Input offset voltage (1)	-40 °C < T <sub>amb</sub> < 125 °C	-9		9	IIIV
$\Delta V_{IO}$	Input offset voltage drift	-40 °C < T <sub>amb</sub> < 125 °C		10	30	μV/°C
V <sub>HYST</sub>	Input hysteresis voltage (2)			2		mV
lio	Input offset current (3)			1	20	
IIO	input onset current 19	-40 °C < T <sub>amb</sub> < 125 °C			100	nΛ
l I <sub>IB</sub>	Input bias current			1	20	рA
IIB	input bias current	-40 °C < T <sub>amb</sub> < 125 °C			100	
		No load, output high		0.47	0.69	
la.	Supply current	No load, output high, -40 °C < T <sub>amb</sub> < 125 °C			0.9	
ICC		No load, output low		0.60	0.91	mA
		No load, output low, -40 °C < T <sub>amb</sub> < 125 °C			1.1	IIIA
l	0, , , , ,	Source	58	62		
Isc	Short circuit current	Sink	58	64		
Vон	Output voltage high	I <sub>source</sub> = 4 mA	4.84	4.89		V
VOH	Output voltage high	-40 °C < T <sub>amb</sub> < 125 °C	4.80			V
Vol	Output voltage low	I <sub>sink</sub> = 4 mA		90	120	mV
VOL	Output voltage low	-40 °C < T <sub>amb</sub> < 125 °C			180	IIIV
CMRR	Common-mode rejection ratio	0 < V <sub>ICM</sub> < 2.7 V	57	74		dB
SVR	Supply voltage rejection	$\Delta V_{CC} = 2.2 \text{ V to 5 V}$		79		uВ
		$C_L = 12 \text{ pF}, R_L = 1 \text{ M}\Omega,$ overdrive = 5 mV		14		
T <sub>PLH</sub>	Propagation delay, low to high output level <sup>(4)</sup>	$C_L = 12 \text{ pF}, R_L = 1 \text{ M}\Omega,$ overdrive = 15 mV		10		ns
	·	$C_L = 12 \text{ pF}, R_L = 1 \text{ M}\Omega,$ overdrive = 50 mV		8	11	



 $<sup>^{(1)}</sup>$ The offset is defined as the average value of positive (V<sub>TRIP+</sub>) and negative (V<sub>TRIP-</sub>) trip points (input voltage differences) requested to change the output state in each direction.

<sup>&</sup>lt;sup>(2)</sup>Hysteresis is a built-in feature of the TS3011. It is defined as the voltage difference between the trip points.

<sup>&</sup>lt;sup>(3)</sup>Maximum values include unavoidable inaccuracies of the industrial tests.

<sup>&</sup>lt;sup>(4)</sup>Overdrive is measured with reference to the V<sub>TRIP+</sub> point.

<sup>&</sup>lt;sup>(5)</sup>Overdrive is measured with reference to the V<sub>TRIP</sub>- point.

### **Electrical characteristics**

### TS3011

Symbol	Parameter	Test conditions	Min.	Тур.	Max.	Unit
		$C_L = 12 \text{ pF}, R_L = 1 \text{ M}\Omega,$ overdrive = 5 mV		16		
T <sub>PHL</sub>	Propagation delay, high to low output level <sup>(5)</sup>	$C_L = 12 \text{ pF}, R_L = 1 \text{ M}\Omega,$ overdrive = 15 mV		11		
		$C_L = 12 \text{ pF}, R_L = 1 \text{ M}\Omega,$ overdrive = 50 mV		9	12	ns
T <sub>R</sub>	Rise time (10 % to 90 %)	$C_L = 12 \text{ pF}, R_L = 1 \text{ M}\Omega,$ overdrive = 100 mV		1.1		
T <sub>F</sub>	Fall time (90 % to 10 %)	$C_L = 12 \text{ pF}, R_L = 1 \text{ M}\Omega,$ overdrive = 100 mV		1.0		

 $<sup>^{(1)}</sup>$ The offset is defined as the average value of positive ( $V_{TRIP+}$ ) and negative ( $V_{TRIP-}$ ) trip points (input voltage differences) requested to change the output state in each direction.

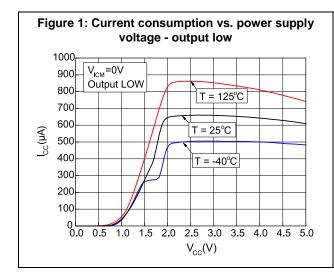
<sup>(2)</sup> Hysteresis is a built-in feature of the TS3011. It is defined as the voltage difference between the trip points.

<sup>(3)</sup> Maximum values include unavoidable inaccuracies of the industrial tests.

 $<sup>\</sup>ensuremath{^{(4)}}\mbox{Overdrive}$  is measured with reference to the VTRIP+ point.

 $<sup>^{(5)}\!\</sup>text{Overdrive}$  is measured with reference to the  $V_{\text{TRIP-}}$  point.

### 4 Electrical characteristic curves



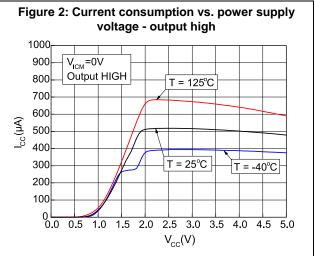
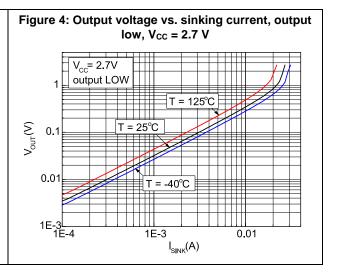


Figure 3: Current consumption vs. temperature

900
800
V<sub>CC</sub> = 5V
700
Output LOW
400
300
-40 -20 0 20 40 60 80 100 120
Temperature (°C)



0.01

Figure 5: Output voltage vs. sinking current, output low,  $V_{CC} = 5 \text{ V}$   $\begin{array}{c}
V_{CC} = 5V \\
\hline
1 & V_{CC} = 5V \\
\hline
0.1 & T = 25^{\circ}C
\end{array}$ 

 $T = -40^{\circ}C$ 

 $I_{SINK}(A)$ 

0.01

0.1

Figure 6: Output voltage drop vs. sourcing current, output high, Vcc = 2.7 V

Output HIGH

T = 125°C

O.01

T = -40°C

IE-3

ISOURCE(A)

Figure 7: Output voltage drop vs. sourcing current, output high, Vcc = 5 V

1E-3

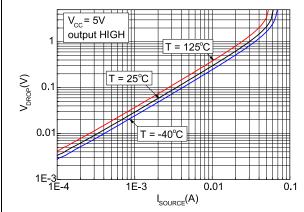


Figure 8: Input offset voltage vs. common mode voltage

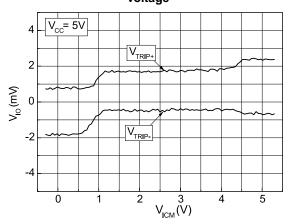


Figure 9: Input offset voltage vs. temperature

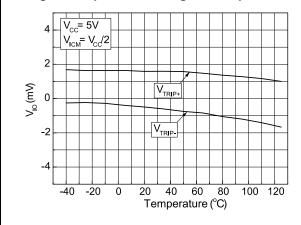


Figure 10: Propagation delay vs. common mode voltage with negative transition

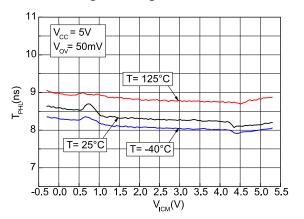
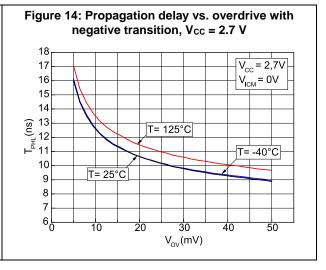
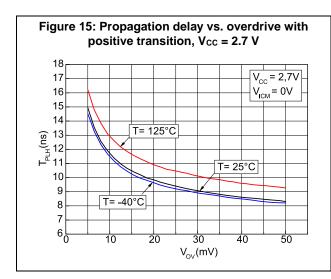


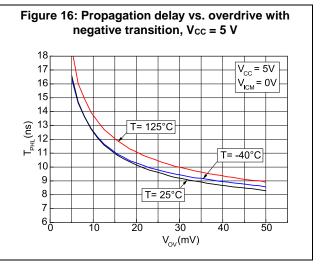
Figure 11: Propagation delay vs. common mode voltage with positive transition

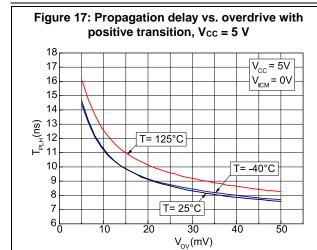
10.0
9.5
V<sub>cc</sub> = 5V
V<sub>oy</sub> = 50mV
9.0
8.5
7.5
7.0
6.5
6.0
-0.5 0.0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5
V<sub>ICM</sub>(V)

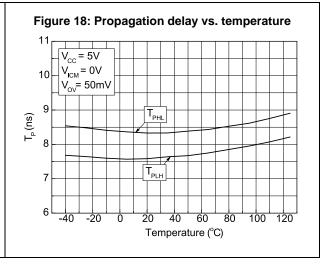
Figure 13: Propagation delay vs. power supply voltage with positive transition 12 V<sub>ICM</sub> = 0V  $V_{ov}$ = 50mV 10 T= 125°C T= -40°C T= 25°C 6<u>L</u> 3.0 4.5 2.5 3.5 4.0 5.0  $V_{cc}(V)$ 











### 5 Application recommendation

When high speed comparators are used, it is strongly recommended to place a capacitor as close as possible to the supply pins. Decoupling has two main advantages for this application: it helps to reduce electromagnetic interference and rejects the ripple that may appear on the output.

A bypass capacitor combination, composed of 100 nF in addition to 10 nF and 1 nF in parallel is recommended because it eliminates spikes on the supply line better than a single 100 nF capacitor. Each millimeter of the PCB track plays an important role. Bypass capacitors must be placed as close as possible to the comparator supply pin. The smallest value capacitor should be preferably placed closer to the supply pin.

In addition, important values of input impedance in series with parasitic PCB capacity and input comparator capacity create an additional RC filter. It generates an additional propagation delay.

For high speed signal applications, PCB must be designed with great care taking into consideration low resistive grounding, short tracks and quality SMD capacitors featuring low ESR. Bypass capacitor stores energy and provides a complementary energy tank when spikes occur on the power supply line. If the input signal frequency is far from the resonant frequency, impedance strongly increases and the capacitor loses bypassing capability. Placing different capacitors with different resonant frequencies allows a wide frequency bandwidth to be covered.

It is also recommended to implement an unbroken ground plane with low inductance.

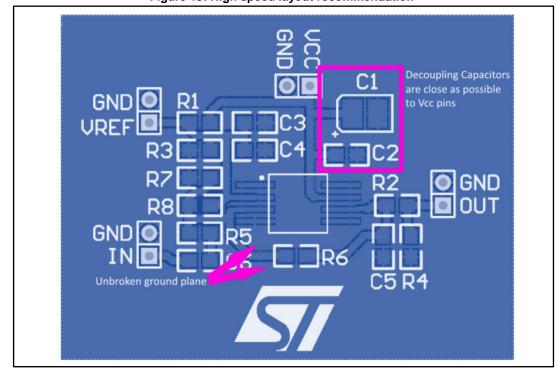


Figure 19: High speed layout recommendation

# 6 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.

TS3011 Package information

# 6.1 SOT23-5 package information

Figure 20: SOT23-5 package outline

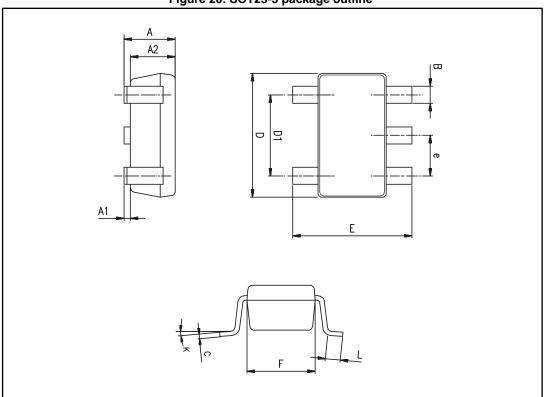


Table 6: SOT23-5 mechanical data

	Dimensions							
Ref.		Millimete	rs	Inches				
	Min.	Тур.	Max.	Min.	Тур.	Max.		
Α	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		
В	0.35	0.40	0.50	0.014	0.016	0.020		
С	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			
е		0.95			0.037			
Е	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		

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

Figure 21: SC70-5 (or SOT323-5) package outline

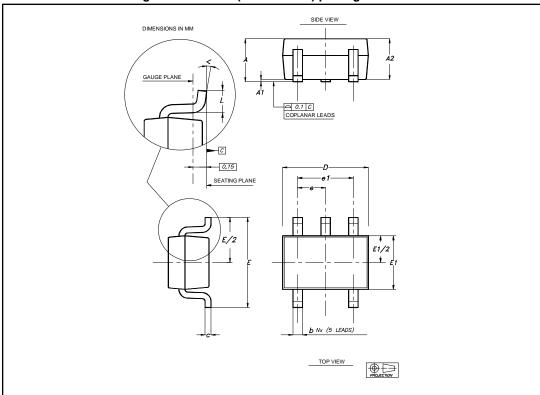


Table 7: SC70-5 (or SOT323-5) mechanical data

	Dimensions							
Ref.		Millimeters			Inches			
	Min.	Тур.	Max.	Min.	Тур.	Max.		
А	0.80		1.10	0.032		0.043		
A1			0.10			0.004		
A2	0.80	0.90	1.00	0.032	0.035	0.039		
b	0.15		0.30	0.006		0.012		
С	0.10		0.22	0.004		0.009		
D	1.80	2.00	2.20	0.071	0.079	0.087		
Е	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		
е		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°		

TS3011 Package information

# 6.3 DFN8 2x2 mm package information

Figure 22: DFN8 2x2 mm package outline

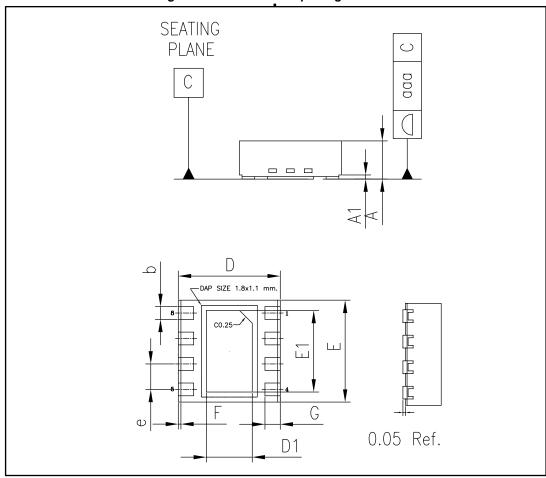


Table 8: DFN8 2x2 mm package mechanical data

	Dimensions						
Ref.		Millimeters		Millimeters Inches			
	Min.	Тур.	Max.	Min.	Тур.	Max.	
А	0.70	0.75	0.80	0.027	0.029	0.031	
A1		0.10			0.003		
b	0.20	0.25	0.30	0.007	0.009	0.011	
D	1.95	2.00	2.05	0.076	0.078	0.080	
D1	0.80	0.90	1.00	0.031	0.035	0.039	
E	1.95	2.00	2.05	0.076	0.078	0.080	
E1	1.50	1.60	1.70	0.059	0.062	0.066	
е		0.50			0.019		
F		0.05			0.001		
G	0.25	0.30	0.35	0.009	0.011	0.013	
aaa		0.10			0.003		

Ordering information TS3011

# 7 Ordering information

Table 9: Order code

Order code	Temperature range	Package	Packaging	Marking
TS3011ILT		COTOO F		K540
TS3011IYLT (1)	40.00 4- 405.00	SOT23-5	Tana and saal	K541
TS3011ICT	-40 °C to 125 °C	SC70-5	Tape and reel	K54
TS3011IYQ3T <sup>(1)</sup>		DFN8 2x2	K5N	

 $<sup>^{(1)}</sup>$  Qualified and characterized according to AEC Q100 and Q003 or equivalent, advanced screening according to AEC Q001 and Q 002 or equivalent.

TS3011 Revision history

# 8 Revision history

Table 10: Document revision history

Date	Revision	Changes
03-Oct-2011	1	Initial release.
18-Feb-2014	2	Updated Table 8: Order codes to add the order code TS3011IYLT.  Added: Automotive qualification among the Features in the cover page.
27-May-2016	3	Updated document layout Section 3: "Electrical characteristics": updated unit of "Input offset voltage drift" parameter to µV/°C (not mV/°C). Section 4: "Electrical characteristic curves": X-axes changed to mV (not V) in figures 15, 16, 17, and 18. Table 6: added "K" values for inches Table 7: updated A and A2 min values for inches and added "<" values for inches.
25-Aug-2017	4	Updated cover page image and description.  Updated Figure 1: "Pin connections (top view)" and Table 9: "Order codes".  Added Section 5.3: "TS3011 DFN package information".
07-Dec-2017	5	Updated Section 1: "Pin configuration".  Added Section 5: "Application recommendation".

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