



### Low-power single voltage comparator





**DFN8 2x2** 

#### **Maturity status link**

TS391, TS391A

#### **Features**

- Wide single supply voltage range or dual supplies 2 V to 36 V or ± 1 V to ± 18 V
- Very low supply current (0.2 mA) independent of supply voltage (1 mW / comparator at 5 V)
- Low input bias current: 25 nA typ.
- Low input offset current: ± 5 nA typ.
- Low input offset voltage: ± 2 mV max. for TS391A
- · Input common-mode voltage range includes ground
- Low output saturation voltage: 250 mV typ. (I<sub>o</sub> = 4 mA)
- Differential input voltage range equal to the supply voltage
- TTL, DTL, ECL, CMOS compatible outputs

#### **Description**

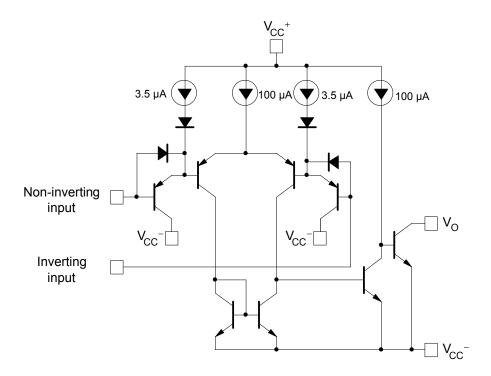
These devices consist of a low-power voltage comparator designed specifically to operate from a single supply over a wide range of voltages. Operation from split power supplies is also possible.

These comparators also have a unique characteristic where the input common-mode voltage range includes ground, even though operated from a single power supply voltage.



# 1 Schematic diagram

Figure 1. Schematic diagram

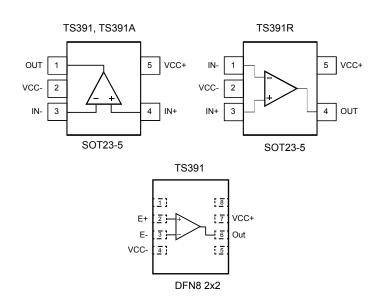


DS1551 - Rev 11 page 2/16



# 2 Package pin connections

Figure 2. Pin connections (top view)



DS1551 - Rev 11 page 3/16



## Absolute maximum ratings and operating conditions

Table 1. Absolute maximum ratings (AMR)

Symbol	Parameter	Value	Unit	
$V_{CC}$	Supply voltage	±18 or 36		
V <sub>id</sub>	Differential input voltage	±36	V	
Vi	Input voltage	-0.3 to 36	V	
Vo	Output voltage (1)		36	
	Output short-circuit to ground (2)	Infinite		
T <sub>j</sub>	Maximum junction temperature		150	°C
T <sub>stg</sub>	Storage temperature range	Storage temperature range		
D	Thermal registeres innertion to ambient (3)	SOT23-5	250	°C/W
R <sub>thja</sub>	Thermal resistance junction to ambient (3)  DFN8 2x2		57	C/VV
	Human body model (HBM) (4)		1500	
ESD	Machine model (MM) (5)	100	V	
	Charged device model (CDM) <sup>(6)</sup>		1000	

- 1. Output voltage can be set up to 36 V even if the  $V_{CC}$  is lower.
- 2. Short-circuits from the output to V<sub>CC</sub> <sup>+</sup> can cause excessive heating and potential destruction. The maximum output current is approximately 20 mA independent of the magnitude of V<sub>CC</sub> <sup>+</sup>.
- 3. Short-circuits can cause excessive heating. These values are typical.
- 4. 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.
- 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). This is done for all couples of connected pin combinations while the other pins are floating.
- 6. Charged device model: all pins and package are charged together to the specified voltage and then discharged directly to ground through only one pin. This is done for all pins.

**Table 2. Operating conditions** 

Symbol	Parameter	Value	Unit	
V <sub>CC</sub>	Supply voltage		2 to 36 or ±1 to ±18	
V <sub>icm</sub>	Institute of the second of the	T <sub>amb</sub> = 25 °C	0 to (V <sub>CC</sub> <sup>+</sup> ) - 1.5	V
	Input common mode voltage range (1) $T_{min} \le T_{amb} \le T_{max}$		0 to (V <sub>CC</sub> +) - 2	
T <sub>oper</sub>	Operating free-air temperature range		-40 to 125	°C

1. The input common-mode voltage of either input signal voltage should not be allowed to go negative by more than 0.3 V. The upper end of the common-mode voltage range is (V<sub>CC</sub> \*) – 1.5 V, but either or both inputs can go to 30 V without damage. As long as one input stays within the Vicm operating range, the comparator will provide a proper output state. Even if the second pin is within 0 V to 30 V.

DS1551 - Rev 11 page 4/16



#### 4 Electrical characteristics

Table 3.  $V_{CC}$  + = 5 V,  $V_{CC}$  - = 0 V,  $T_{amb}$  = 25 °C (unless otherwise specified)

Symbol		Parameter and test conditions			Max.	Unit	
V <sub>io</sub>	Input offset voltage			1	5		
	TS391	Input offset voltage, $T_{min} \le T_{amb} \le T_{max}$			9	\ /	
	TS391A	Input offset voltage (1)		1	1.5	mV	
	13391A	Input offset voltage, $T_{min} \le T_{amb} \le T_{max}$			2		
	TS391	Input bias current		25	250		
l.,	13391	Input bias current, $T_{min} \le T_{amb} \le T_{max}$			400		
l <sub>ib</sub>	TS391A	Input bias current (2)		25	150	nA	
	13391A	Input bias current, $T_{min} \le T_{amb} \le T_{max}$			250	IIA	
l <sub>io</sub>	Input offset cu	irrent		5	50		
110	Input offset cu	ırrent, T <sub>min</sub> ≤ T <sub>amb</sub> ≤ T <sub>max</sub>			150		
A <sub>VD</sub>	Large signal v	voltage gain, (V <sub>CC +</sub> ) = 15 V, R <sub>L</sub> =15 k $\Omega$ , V <sub>o</sub> = 1 to 11 V	50	200		V/mV	
	Supply current (V <sub>CC</sub> <sup>+</sup> ) = 5 V, no load			0.2	0.5		
I <sub>CC</sub>	Supply current (V <sub>CC</sub> <sup>+</sup> ) = 30 V, no load			0.5	1.25	mA mA	
V <sub>id</sub>	Differential inp			V <sub>CC</sub> +	V		
I <sub>sink</sub>	Output sink cu	urrent, V <sub>id</sub> = - 1 V, V <sub>o</sub> = 1.5 V	6	16		mA	
	Low level outp	out voltage, V <sub>id</sub> = 1 V, V <sub>CC</sub> <sup>+</sup> = 30 V, T = T <sub>amb</sub>		250	400		
V <sub>OL</sub>	Low level output voltage, $V_{id}$ = 1 V, $V_{CC}$ + = 30 V,				700	mV	
	$T_{min} \le T_{amb} \le T_{max}$				700		
	High level out	put current, V <sub>id</sub> = 1 V, V <sub>CC</sub> <sup>+</sup> = V <sub>o</sub> = 30 V, T = T <sub>amb</sub>		0.1		nA	
I <sub>OH</sub>	High level output current, $V_{id} = 1 \text{ V}$ , $V_{CC}^+ = V_o = 30 \text{ V}$ ,				_		
	$T_{min} \le T_{amb} \le T_{max}$				1	μA	
t <sub>re</sub>	Small signal response time, $R_L$ = 5.1 k $\Omega$ to $(V_{CC+})^{(4)}$			1.3		μs	
t <sub>rel</sub>	Large signal response time, $V_i$ = TTL, $V_{ref}$ = 1.4 V, $R_L$ = 5.1 k $\Omega$ to $V_{CC}$ <sup>+</sup>			300		ns	

<sup>1.</sup> At the output switch point,  $V_0 \approx 1.4 \text{ V}$ ,  $R_S = 0 \Omega$  with  $(V_{CC}^+)$  from 5 V to 30 V, and over the full input common-mode range (0 V to  $(V_{CC}^+) - 1.5 \text{ V})$ 

4. The response time specified is for a 100 mV input step with 5 mV overdrive. For larger overdrive signals, 300 ns can be obtained.

DS1551 - Rev 11 page 5/16

<sup>2.</sup> The direction of the input current is out of the IC due to the PNP input stage. This current is essentially constant, independent of the state of the output, so there is no load charge on the reference of input lines.

<sup>3.</sup> Positive excursions of the input voltage may exceed the power supply level. As long as the other voltage remains within the common-mode range, the comparator will provide a proper output state. The low input voltage state must not be less than -0.3 V (or 0.3 V below the negative power supply, if used)



#### 5 Electrical characteristic curves

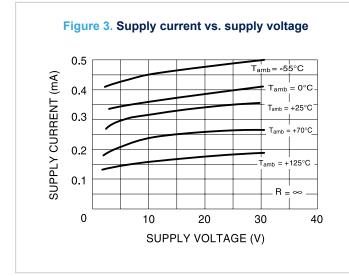
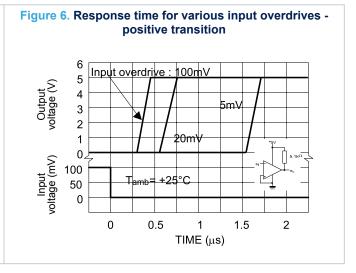
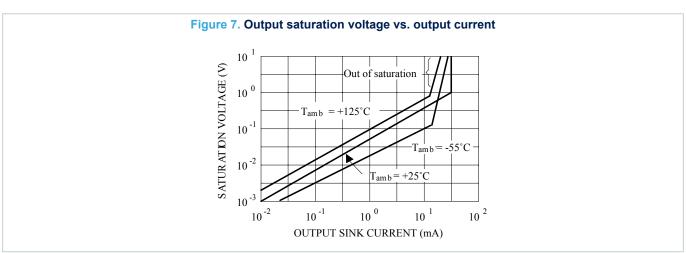


Figure 4. Response time for various input overdrives negative transition 6 Input overdrive : 5mV 5 4 20<sub>m</sub>V 3 2 1 100m\ 0 Input voltage (mV) 0 -50  $T_{amb} = +25^{\circ}C$ -100 0.5 1.5 0 1 2 TIME (µs)

Figure 5. Input current vs. supply voltage 80  $V_i = 0V$  $R_i = 10^9 \Omega$  $T_{amb} = -55^{\circ}C$ INPUT CURRENT (nA) 60  $T_{amb} = 0^{\circ}C$ 40  $T_{amb} = +25^{\circ}C$ 20  $T_{amb} = +125^{\circ}C$  $T_{am\,b} = +70^{\circ}C$ 0 20 40 SUPPLY VOLTAGE (V)





DS1551 - Rev 11 page 6/16



## 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.

DS1551 - Rev 11 page 7/16



## 6.1 SOT23-5 package information

Figure 8. SOT23-5 package outline

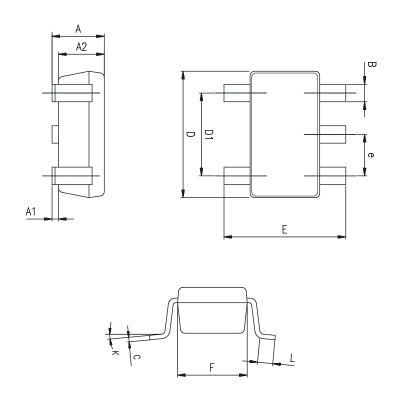


Table 4. SOT23-5 mechanical data

	Dimensions						
Ref.	Millimeters			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		
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	

DS1551 - Rev 11 page 8/16



## 6.2 DFN8 2 x 2 package information

SEATING PLANE

C

PIN#1 ID

Figure 9. DFN8 2 x 2 package outline

Table 5. DFN8 2 x 2 mechanical data

	Dimensions					
Ref.	Millimeters			Inches		
	Min.	Тур.	Max.	Min.	Тур.	Max.
Α	0.51	0.55	0.60	0.020	0.022	0.024
A1			0.05			0.002
A3		0.15			0.006	
b	0.18	0.25	0.30	0.007	0.010	0.012
D	1.85	2.00	2.15	0.073	0.079	0.085
D2	1.45	1.60	1.70	0.057	0.063	0.067
E	1.85	2.00	2.15	0.073	0.079	0.085
E2	0.75	0.90	1.00	0.030	0.035	0.039
е		0.50			0.020	
L	0.225	0.325	0.425	0.009	0.013	0.017
ddd			0.08			0.003

DS1551 - Rev 11 page 9/16



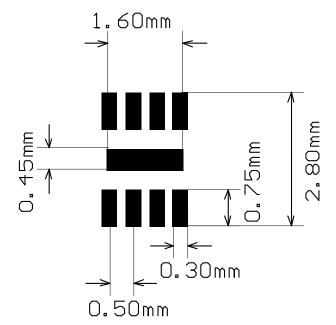


Figure 10. DFN8 2 x 2 recommended footprint

DS1551 - Rev 11 page 10/16



# 7 Ordering information

Table 6. Order codes

Part number	Temperature range	Package	Packaging	Marking
TS391ILT		SOT23-5		K511
TS391AILT		50123-5		K512
TS391IYLT (1)	-40 °C to 125 °C	SOT23-5 (automotive grade)	Tono and soal	K510
TS391RILT	-40 °C to 125 °C	SOT23-5	Tape and reel	K509
TS391RIYLT (1)		SOT23-5 (automotive grade)		K535
TS391IQ2T		DFN8 2x2		K5D

Qualification and characterization according to AEC Q100 and Q003 or equivalent, advanced screening according to AEC Q001 & Q002 or equivalent.

DS1551 - Rev 11 page 11/16



## **Revision history**

Table 7. Document revision history

Date	Revision	Changes
22-Sep-2004	1	Initial release.
06-Jan-2006	2	PPAP reference inserted in the document.
		Added values for R <sub>thja</sub> , R <sub>thjc</sub> and ESD in Table 1: Absolute maximum ratings (AMR).
21-Nov-2007	3	Added footnote for automotive grade order code in order codes table.
		Updated format.
21-Jan-2010	4	Corrected ESD tolerance values for human body model and machine model in Table 1: Absolute maximum ratings (AMR) and added ESD tolerance value for charged device model.
		Updated note 1 in Table 6: Order codes.
		Added TS391R pinout on page 1.
23-May-2011	5	Modified V <sub>CC</sub> range in Table 2: Operating conditions.
		Added TS391RILT order code in Table 6: Order codes.
02-Mar-2012	6	Added DFN8 package information and changed SOT23-5L package drawing in Chapter 4.
		Removed letter "L" and "plastic package" from SOT23-5 silhouette and letters "Q2" and "plastic micropackage" from DFN8 2x2 silhouette.
		Standardized name of the DFN8 package to: "DFN8 2x2" throughout datasheet.
06-Nov-2015	7	Table 1: "Absolute maximum ratings (AMR)": added parameter V <sub>o</sub> .
		Table 4: "SOT23-5 mechanical data": updated "K" parameter.
		Table 5: "DFN8 2 x 2 mechanical data": updated "L" parameter.
		Added new part number TS391A.
20-Mar-2017	8	Features: updated low input offset voltage for TS391A.
20-IVIAI-2017	0	Table 3: added Vio and lib information for TS391A.
		Table 6: "Order codes": added new order code TS391AILT.
06-Mar-2020	9	Table 6 added new order code TS391RIYLT.
14-Jan-2021	10	Updated Figure 3. Pin connections (top view).
04-Sep-2023	11	Updated V <sub>OL</sub> and I <sub>OH</sub> relation of parameters in Table 3.

DS1551 - Rev 11 page 12/16



## **Contents**

1	Sch	ematic diagram	2	
2	Pac	kage pin connections	3	
3	Abs	olute maximum ratings and operating conditions	4	
4	Elec	ctrical characteristics	5	
5	Electrical characteristic curves			
6	Pac	kage information	7	
		SOT23-5 package information		
	6.2	DFN8 2 x 2 package information	9	
7	Ord	ering information	11	
Rev	ision	history	12	



## **List of tables**

Table 1.	Absolute maximum ratings (AMR)	4
Table 2.	Operating conditions	4
Table 3.	$V_{CC}^+$ = 5 V, $V_{CC}^-$ = 0 V, $T_{amb}$ = 25 °C (unless otherwise specified)	5
Table 4.	SOT23-5 mechanical data	8
Table 5.	DFN8 2 x 2 mechanical data	Ĉ
Table 6.	Order codes	11
Table 7.	Document revision history	12

DS1551 - Rev 11 page 14/16



# **List of figures**

Figure 1.	Schematic diagram	. 2
Figure 2.	Pin connections (top view)	. 3
Figure 3.	Supply current vs. supply voltage	. 6
Figure 4.	Response time for various input overdrives - negative transition	. 6
Figure 5.	Input current vs. supply voltage	. 6
Figure 6.	Response time for various input overdrives - positive transition	. 6
Figure 7.	Output saturation voltage vs. output current	. 6
Figure 8.	SOT23-5 package outline	. 8
Figure 9.	DFN8 2 x 2 package outline	. 9
Figure 10.	DFN8 2 x 2 recommended footprint	10

DS1551 - Rev 11 page 15/16



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DS1551 - Rev 11 page 16/16