TSZ901

Datasheet

Very high accuracy (5 µV) high bandwidth (10 MHz) zero drift 5 V op amp

TSZ901

SOT23-5

Maturity status link
TSZ901

Products	Channel	Automotive	Package
TSZ901ILT	1		SOT23-5
TSZ901IYLT	1	•	SOT23-5

Related products	
TSZ181	Zero-drift amplifier for lower power consumption (3 MHz, 800 µA)
TSV771	High-accuracy (200 µV) 5 V amplifier with wider bandwidth (20 MHz)

Features

- Very high accuracy and stability: offset voltage
  - 5 µV max. at 25 °C
  - 8 µV over the full temperature range (-40 °C to 125 °C)
- Rail-to-rail input and output
- Low supply voltage: 2.5 - 5.5 V
- Low power consumption: 1.5 mA at 5 V
- Gain-bandwidth product: 10 MHz
- AEC-Q100 automotive qualification
- Extended temperature range: -40 °C to 125 °C
- Benefits:
  - Higher accuracy without calibration
  - Accuracy virtually unaffected by temperature change

Applications

- High-accuracy signal conditioning
- Automotive current measurement and sensor signal conditioning

Description

The TSZ901 is a single operational amplifier featuring very low offset voltages with virtually zero drift over temperature changes.

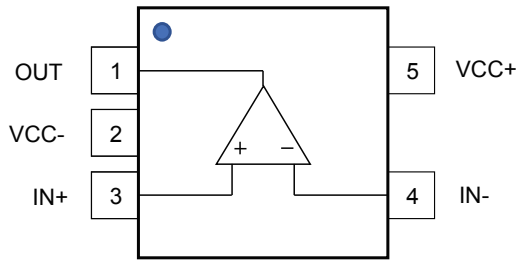
The TSZ901 offers rail-to-rail input and output, excellent speed/power consumption ratio, and a 10 MHz gain-bandwidth product, while consuming just 1.5 mA at 5 V.

The device also features an ultra-low input bias current. These features make the TSZ901 ideal for high-accuracy sensor interfaces.

1 Pin description

1.1 TSZ901 single operational amplifier (SOT23-5)

Figure 1. Pin connections (top view)



SOT23-5

Table 1. Pin description

Pin n°	Pin name	Description
1	OUT	Output channel
2	VCC-	Negative supply voltage
3	IN+	Non-inverting input channel
4	IN-	Inverting input channel
5	VCC+	Positive supply voltage

2 Maximum ratings

Table 2. Absolute maximum ratings

Symbol	Parameter [1]	Value	Unit
V_{CC}	Supply voltage	6	V
V_{id}	Input voltage differential (V_{IN+} - V_{IN-})	$\pm V_{CC}$	V
V_{in}	Input voltage [2]	(V_{CC-}) - 0.2 to (V_{CC+}) + 0.2	V
I_{in}	Input current	±10	mA
T_{stg}	Storage temperature	-65 to +150	°C
T_j	Maximum junction temperature	150	
R_{th-ja} [3]	Thermal resistance junction-to-ambient		°C/W
	SOT23-5	250	
T_j	Maximum junction temperature	150	°C
ESD	HBM: human body model (industrial grade) [4]	4	kV
	HBM: human body model (automotive grade) [5]	4	kV
	CDM: charged device model [6]	1	kV

1. *All voltage values are with respect to the VCC- pin, unless otherwise specified.*
2. *The maximum input voltage differential value may be extended under the condition that the input current is limited to ±10 mA.*
3. *R_{th-ja} is a typical value, obtained with PCB according to JEDEC 2s2p without vias.*
4. *Human body model: HBM test according to the standard ESDA-JS-001-2017.*
5. *Human body model: HBM test according to the standard AEC-Q100-002.*
6. *Charged device model: the CDM test is performed according to the standard AEC-Q100-011.*

Table 3. Operating conditions

Symbol	Parameter	Value	Unit
V_{CC}	Supply voltage	2.5 to 5.5	V
V_{icm}	Common-mode input voltage range	V_{CC-} – 0.1 V to V_{CC+} + 0.1 V	V
T_{oper}	Operating free-air temperature range	-40 to 125	°C

3 Electrical characteristics

Table 4. Electrical characteristics at V_{CC} = 5 V, V_{icm} = V_{OUT} = V_{CC} / 2, T = 25 °C, C_L = 47 pF and R_L = 10 kΩ connected to V_{CC} / 2 (unless otherwise specified).

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
DC performance						
V_{io}	Input offset voltage	T = 25 °C		± 1	± 5	µV
		-40 °C ≤ T ≤ 125 °C			± 8	
$\Delta V_{io}/\Delta T$ (1)	Input offset voltage drift over temperature	-40 °C ≤ T ≤ 125 °C		±10	±30	nV/°C
I_{ib} (2)	Input bias current	T = 25 °C		200		pA
		-40 °C ≤ T ≤ 125 °C		300		
I_{io} (2)	Input offset current	T = 25 °C		200		pA
		-40 °C ≤ T ≤ 125 °C		300		
A_{VD}	Open-loop gain	R_L = 2 kΩ, V_{CC-} + 150 mV ≤ V_{OUT} ≤ V_{CC+}- 150 mV, T = 25 °C	126	135		dB
		-40 °C ≤ T ≤ 125 °C	120			
CMR	Common-mode rejection ratio 20.log($\Delta V_{io}/\Delta V_{icm}$)	V_{CC-} ≤ V_{icm} ≤ V_{CC+},T = 25 °C	115	122		dB
		V_{CC-} ≤ V_{icm} ≤ V_{CC+}, -40 °C ≤ T ≤ 125 °C	115			
SVR	Supply-voltage rejection ratio 20.log($\Delta V_{io}/\Delta V_{CC}$)	2.5 V ≤ V_{CC} ≤ 5.5 V, T = 25 °C, V_{icm} = 0 V	115	140		dB
		2.5 V ≤ V_{CC} ≤ 5.5 V, -40 °C ≤ T ≤ 125 °C, V_{icm} = 0 V	115			
V_{OH}	High-level output voltage drop (V_{OH} = V_{CC+} - V_{OUT})	R_L = 2 kΩ, T = 25 °C			50	mV
		R_L = 2 kΩ , -40 °C ≤ T ≤ 125 °C			70	
V_{OL}	Low-level output voltage drop (V_{OL} = V_{OUT})	R_L = 2 kΩ, T = 25 °C			50	mV
		R_L = 2 kΩ , -40 °C ≤ T ≤ 125 °C			70	
I_{OUT}	I_{SINK}	OUT connected to V_{CC+}, T = 25 °C	35	50		mA
		OUT connected to V_{CC+}, -40 °C ≤ T ≤ 125 °C	25			
	I_{SOURCE}	OUT connected to V_{CC-}, T = 25 °C	35	50		
		OUT connected to V_{CC-}, -40 °C ≤ T ≤ 125 °C	25			
I_{CC}	Supply current (per operational amplifier)	T = 25°C		1.5	2.0	mA
		-40 °C ≤ T ≤ 125 °C			2.0	
AC performance						
GBP	Gain-bandwidth product	R_L = 10 kΩ		10		MHz
SR	Slew rate	R_L = 10 kΩ, AV = 1V/V, 10% to 90%	3.5	6		V/µs
Φm	Phase margin	R_L = 10 kΩ		50		degrees
e_n	Input voltage noise density	f = 1 kHz		9		nV/√Hz
		f = 10 kHz		9		
$e_{n\ p-p}$	Input noise voltage	0.1 Hz ≤ f ≤ 10 Hz		0.2		µVpp
t_{rec}	Overload recovery time	V_{IN} from (V_{CC+} + 100 mV) to (V_{CC+} -1 V) , V_{OUT} measured at (V_{CC+} - 100 mV), AV = +1		2		µs
t_{init}	Initialization time, V_{OUT} at 100 mV from final value	T = 25 °C		50		µs
		-40 °C ≤ T ≤ 125 °C		100		

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
t_s	Settling time	V_{OUT} to 0.1%, Vin = 1 Vp-p, AV = - 1V/V		1		µs
EMIRR	EMI rejection rate = - 20log ($V_{RFpeak}/\Delta V_{io}$)	V_{RF} = 100 mVp, f = 400 MHz		84		dB
		V_{RF} = 100 mVp, f = 900 MHz		87		
		V_{RF} = 100 mVp, f = 1800 MHz		90		
		V_{RF} = 100 mVp, f = 2400 MHz		91		

1. *See Section 4.2: Input offset voltage drift over the temperature.*
2. *Guaranteed by design and characterization on a sample of parts, not tested in production.*

Table 5. Electrical characteristics at V_{CC} = 3.3 V, V_{icm} = V_{OUT} = V_{CC} / 2, T = 25 °C, C_L = 47 pF and R_L = 10 kΩ connected to V_{CC} / 2 (unless otherwise specified).

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
DC performance						
V_{io}	Input offset voltage	T = 25 °C		± 1	± 6	µV
		-40 °C ≤ T ≤ 125 °C			± 8	
$\Delta V_{io}/\Delta T$ (1)	Input offset voltage drift over temperature	-40 °C ≤ T ≤ 125 °C		±10	±30	nV/°C
I_{ib} (2)	Input bias current	T = 25 °C		200		pA
		-40 °C ≤ T ≤ 125 °C		300		
I_{io} (2)	Input offset current	T = 25 °C		200		pA
		-40 °C ≤ T ≤ 125 °C		300		
A_{VD}	Open=loop gain	R_L = 2 kΩ, V_{CC-} + 150 mV ≤ V_{OUT} ≤ V_{CC+}- 150 mV, T = 25 °C	126	135		dB
		-40 °C ≤ T ≤ 125 °C	120			
CMR	Common-mode rejection ratio 20.log($\Delta V_{io}/\Delta V_{icm}$)	V_{CC-} ≤ V_{icm} ≤ V_{CC+},T = 25 °C	115	122		dB
		V_{CC-} ≤ V_{icm} ≤ V_{CC+}, -40 °C ≤ T ≤ 125 °C	115			
V_{OH}	High-level output voltage drop (V_{OH} = V_{CC+} - V_{OUT})	R_L = 2 kΩ, T = 25 °C			33	mV
		R_L = 2 kΩ , -40 °C ≤ T ≤ 125 °C			49	
V_{OL}	Low-level output voltage drop (V_{OL} = V_{OUT})	R_L = 2 kΩ, T = 25 °C			33	mV
		R_L = 2 kΩ , -40 °C ≤ T ≤ 125 °C			49	
I_{OUT}	I_{SINK}	OUT connected to V_{CC+}, T = 25 °C	35	50		mA
		OUT connected to V_{CC+}, -40 °C ≤ T ≤ 125 °C	25			
	I_{SOURCE}	OUT connected to V_{CC-}, T = 25 °C	35	50		
		OUT connected to V_{CC-}, -40 °C ≤ T ≤ 125 °C	25			
I_{CC}	Supply current (by operational amplifier)	T = 25°C		1.5	2.0	mA
		-40 °C ≤ T ≤ 125 °C			2.0	
AC performance						
GBP	Gain-bandwidth product	R_L = 10 kΩ		10		MHz
SR	Slew rate	R_L = 10 kΩ, AV = 1V/V, 10% to 90%	3.5	6		V/µs
Φm	Phase margin	R_L = 10 kΩ		50		degrees
e_n	Input voltage noise density	f = 1 kHz		9		nV/√Hz
		f = 10 kHz		9		
$e_{n\ p-p}$	Input noise voltage	0.1 Hz ≤ f ≤ 10 Hz		0.2		µVpp
t_{rec}	Overload recovery time	V_{IN} from (V_{CC+} + 100 mV) to (V_{CC+} -1 V) , V_{OUT} measured at (V_{CC+} - 100 mV), AV = +1		2		µs
t_{init}	Initialization time, V_{OUT} at 100 mV from final value	T = 25 °C		50		µs
		-40 °C ≤ T ≤ 125 °C		100		
t_s	Settling time	V_{OUT} to 0.1%, Vin = 1 Vp-p, AV = - 1V/V		1		µs

1. *See Section 4.2: Input offset voltage drift over the temperature.*
2. *Guaranteed by design and characterization on a sample of parts, not tested in production.*

Table 6. Electrical characteristics at V_{CC} = 2.5 V, V_{icm} = V_{OUT} = V_{CC} / 2, T = 25 °C, C_L = 47 pF and R_L = 10 kΩ connected to V_{CC} / 2 (unless otherwise specified).

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
DC performance						
V_{io}	Input offset voltage	T = 25 °C		± 1	± 6	µV
		-40 °C ≤ T ≤ 125 °C			± 8	
$\Delta V_{io}/\Delta T$ (1)	Input offset voltage drift over temperature	-40 °C ≤ T ≤ 125 °C		±10	±30	nV/°C
I_{ib} (2)	Input bias current	T = 25 °C		200		pA
		-40 °C ≤ T ≤ 125 °C		300		
I_{io} (2)	Input offset current	T = 25 °C		200		pA
		-40 °C ≤ T ≤ 125 °C		300		
A_{VD}	Open-loop gain	R_L = 2 kΩ, V_{CC-} + 150 mV ≤ V_{OUT} ≤ V_{CC+}- 150 mV, T = 25 °C	126	135		dB
		-40 °C ≤ T ≤ 125 °C	120			
CMR	Common-mode rejection ratio 20.log($\Delta V_{io}/\Delta V_{icm}$)	V_{CC-} ≤ V_{icm} ≤ V_{CC+}, T = 25 °C	110	122		dB
		V_{CC-} ≤ V_{icm} ≤ V_{CC+}, -40 °C ≤ T ≤ 125 °C	110			
V_{OH}	High-level output voltage drop (V_{OH} = V_{CC+} - V_{OUT})	R_L = 2 kΩ, T = 25 °C			25	mV
		R_L = 2 kΩ , -40 °C ≤ T ≤ 125 °C			35	
V_{OL}	Low-level output voltage drop (V_{OL} = V_{OUT})	R_L = 2 kΩ, T = 25 °C			25	mV
		R_L = 2 kΩ , -40 °C ≤ T ≤ 125 °C			35	
I_{OUT}	I_{SINK}	OUT connected to V_{CC+}, T = 25 °C	35	50		mA
		OUT connected to V_{CC+}, -40 °C ≤ T ≤ 125 °C	25			
	I_{SOURCE}	OUT connected to V_{CC-}, T = 25 °C	35	50		
		OUT connected to V_{CC-}, -40 °C ≤ T ≤ 125 °C	25			
I_{CC}	Supply current (by operational amplifier)	T = 25°C		1.5	2.0	mA
		-40 °C ≤ T ≤ 125 °C			2.0	
AC performance						
GBP	Gain-bandwidth product	R_L = 10 kΩ		10		MHz
SR	Slew rate	R_L = 10 kΩ, AV = 1V/V, 10% to 90%	3.5	6		V/µs
Φm	Phase margin	R_L = 10 kΩ		50		degrees
e_n	Input voltage noise density	f = 1 kHz		9		nV/√Hz
		f = 10 kHz		9		
$e_{n\ p\text{-}pT}$	Input noise voltage	0.1 Hz ≤ f ≤ 10 Hz		0.2		µVpp
t_{rec}	Overload recovery time	V_{IN} from (V_{CC+} + 100 mV) to (V_{CC+} -1 V) , V_{OUT} measured at (V_{CC+} - 100 mV), AV = +1		2		µs
t_{init}	Initialization time, V_{OUT} at 100 mV from final value	T = 25 °C		50		µs
		-40 °C ≤ T ≤ 125 °C		100		
t_s	Settling time	V_{OUT} to 0.1%, Vin = 1 Vp-p, AV = - 1V/V		1		µs

1. *See Section 4.2: Input offset voltage drift over the temperature.*
2. *Guaranteed by design and characterization on a sample of parts, not tested in production.*

4 Application information

4.1 Operating voltages

The TSZ901 device can operate from 2.5 to 5.5 V. The parameters are fully specified at 2.5 V, 3.3 V and 5 V power supplies. However, the parameters are very stable over the full V_{CC} range and several characterization curves show the TSZ901 device characteristics over the full operating range. Additionally, the main specifications are guaranteed over an extended temperature range from -40 to 125 °C.

4.2 Input offset voltage drift over the temperature

The maximum input voltage drift variation over temperature is defined as the offset variation related to the offset value measured at 25 °C. The operational amplifier is one of the main circuits of the signal conditioning chain, and the amplifier input offset (V_{io}) is a major contributor to the chain accuracy. The signal chain accuracy at 25 °C can be compensated during production at application level. The maximum input voltage drift over temperature enables the system designer to anticipate the effect of temperature variations. The maximum input voltage drift over temperature is computed using Equation 1.

$$\frac{\Delta V_{io}}{\Delta T} = \max\left|\frac{V_{io\_T} - V_{io\_25°C}}{T - 25°C}\right|_{T = -40°C \text{ and } T = 125°C} \quad (1)$$

The datasheet maximum value is guaranteed by a measurement on a representative sample size ensuring a Cpk (process capability index) greater than 1.3.

4.3 Maximum power dissipation

The usable output load current drive is limited by the maximum power dissipation allowed by the device package. The absolute maximum junction temperature for the TSZ901 is 150 °C. The junction temperature can be estimated as follows:

$$T_J = P_D \times \theta_{JA} + T_A \quad (2)$$

T_J is the die junction temperature.

P_D is the power dissipated in the package.

θ_{JA} is the junction to thermal resistance of the package.

T_A is the ambient temperature.

The power dissipated in the package P_D is the sum of the quiescent power dissipated and the power dissipated by the output stage transistor. It is calculated as follows:

$P_D = (V_{CC} \times I_{CC}) + (V_{CC+} - V_{OUT}) \times I_{OUT}$ when the op amp is sourcing the current.

$P_D = (V_{CC} \times I_{CC}) + (V_{OUT} - V_{CC-}) \times I_{OUT}$ when the op amp is sinking the current.

Do not exceed the 150 °C maximum junction temperature for the device. Exceeding the junction temperature limit can cause degradation in the parametric performance or even destroy the device.

4.4 PCB layout recommendations

Particular attention must be paid to the layout of the PCB tracks connected to the amplifier, load, and power supply. The power and ground traces are critical as they must provide adequate energy and grounding for all circuits. The best practice is to use short and wide PCB traces to minimize voltage drops and parasitic inductance. In addition, to minimize parasitic impedance over the entire surface, a multi-via technique that connects the bottom and top layer ground planes together in many locations is often used. The copper traces that connect the output pins to the load and supply pins should be as wide as possible to minimize trace resistance.

4.5 Decoupling capacitor

In order to ensure full functionality of the op amp, it is mandatory to place a decoupling capacitor of at least 22 nF as close as possible to the op amp supply pin. Proper decoupling will help to reduce electromagnetic interference impact.

4.6 Macromodel

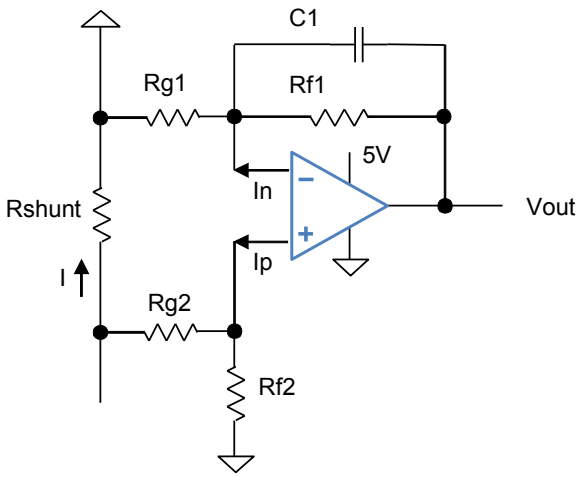
Accurate macromodels of the TSZ901 device are available on the STMicroelectronics website at www.st.com. These models are a trade-off between accuracy and complexity (that is, time simulation) of the TSZ901 operational amplifier. They emulate the nominal performance of a typical device within the specified operating conditions mentioned in the datasheet. They also help to validate a design approach and to select the right operational amplifier, but they do not replace on-board measurements.

5 Typical applications

5.1 Low-side current sensing

Power management mechanisms are found in most electronic systems. Current sensing is useful for protecting applications. The low-side current sensing method consists of placing a sense resistor between the load and the circuit ground. The resulting voltage drop is amplified using the TSZ901.

Figure 2. Low-side current sensing schematic



V_{out} can be expressed as follows:

$$V_{out} = R_{shunt} \cdot I\left(1 - \frac{Rg2}{Rg2 + Rf2}\right) \cdot \left(1 + \frac{Rf1}{Rf2}\right) + I_p \cdot \frac{Rg2 \cdot Rf2}{Rg2 + Rf2} \cdot \left(1 + \frac{Rf1}{Rg1}\right) - I_n \cdot Rf1 - V_{io} \cdot \left(1 + \frac{Rf1}{Rg1}\right) \quad (3)$$

Assuming that Rf2 = Rf1 = Rf and Rg2 = Rg1 = Rg, Equation 3 can be simplified as follows:

$$V_{out} = R_{shunt} \cdot I \cdot \frac{Rf}{Rg} - V_{io} \cdot \left(1 + \frac{Rf}{Rg}\right) + Rf \cdot I_{io} \quad (4)$$

The main advantage of using the TSZ901 for a low-side current sensing relies on its low V_{io}, compared to general purpose operational amplifiers. For the same current and targeted accuracy, the shunt resistor can be chosen with a lower value, resulting in lower power dissipation, lower drop in the ground path, and lower cost. Particular attention must be paid to the precision of Rg1 and Rf1, to maximize the accuracy of the measurement.

Note that the open-loop gains of the TSZ901 are defined close to the rail. It enables measurements over a wide range of currents.

6 Package information

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.

6.1 SOT23-5 package information

Figure 3. SOT23-5 package outline

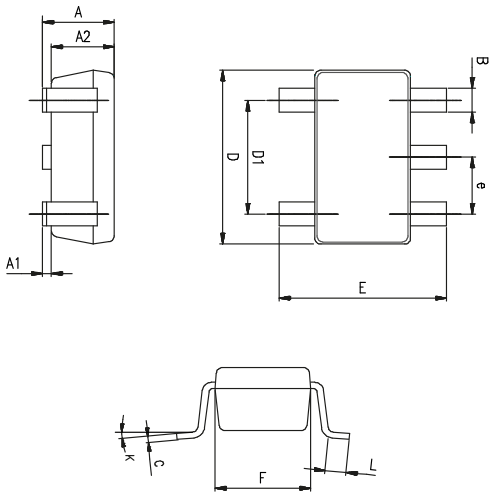


Table 7. SOT23-5 package mechanical data

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	0.014	0.016	0.020
C	0.09	0.15	0.20	0.004	0.006	0.020
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°		10°	0°		10°

7 Ordering information

Table 8. Order codes

Order code	Temperature range	Package	Marking
TSZ901ILT	-40 °C to 125 °C	SOT23-5	K250
TSZ901IYLT	-40 °C to 125 °C, automotive grade (1)	SOT23-5	K251

1. *Qualification and characterization according to AEC Q100 and Q003 or equivalent, advanced screening according to AEC Q001 & Q002 or equivalent. For qualification status detail, check " Maturity Status Link " on first page (" Quality & Reliability " tab on www.st.com).*

Revision history

Table 9. **Document revision history**

Date	Revision	Changes
16-Sep-2025	1	Initial release.

Contents

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