Op amps & comparators
Amplify your performance

Contents

Introduction

STMicroelectronics offers a wide analog portfolio including operational amplifiers and comparators dedicated to the challenging industrial, automotive, and consumer markets.

The product range allows easy and fast integration of analog products inside signal conditioning, monitoring, and control solutions. It also covers specific requirements including precision, low consumption, high speed, cost-optimized bills of material.

ST op amps enhance the signal chain by being the perfect companion chips for microcontrollers and analog sensors.

OPERATIONAL AMPLIFIERS

- Low power
- Precision
- Low input bias current
- Low V_{cc} min
- High V_{cc} max
- Speed
- Small packages
- EMI hardened
- High temperature
- Low-power audio
- Current sense amplifier
- Automotive

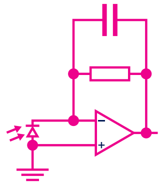
COMPARATORS

- Micropower
- Speed
- Small packages
- High temperature
- Automotive

Application schematics examples

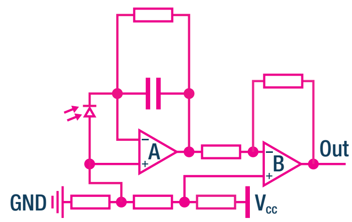
SIGNAL CONDITIONING FOR ENVIRONMENTAL MONITORING AND DETECTION

Photodiode current sensing



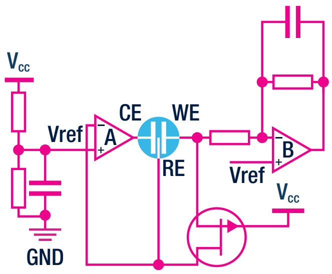
FEATURED PRODUCTS:
- TSU series
- TSX series
- TSV63 series
- TSV7 series

Smoke detector



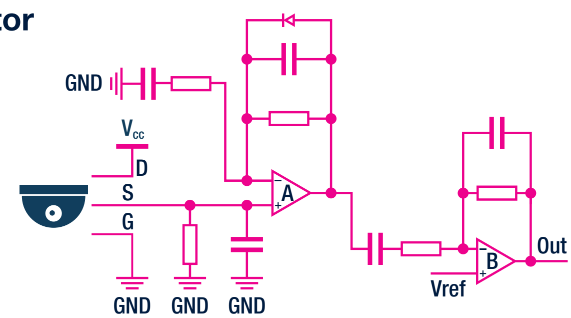
FEATURED PRODUCTS:
- TSV629 series
- TSV5 series
- TSV7 series

CO detector



FEATURED PRODUCTS:
- TSU series
- TSZ series

PIR detector

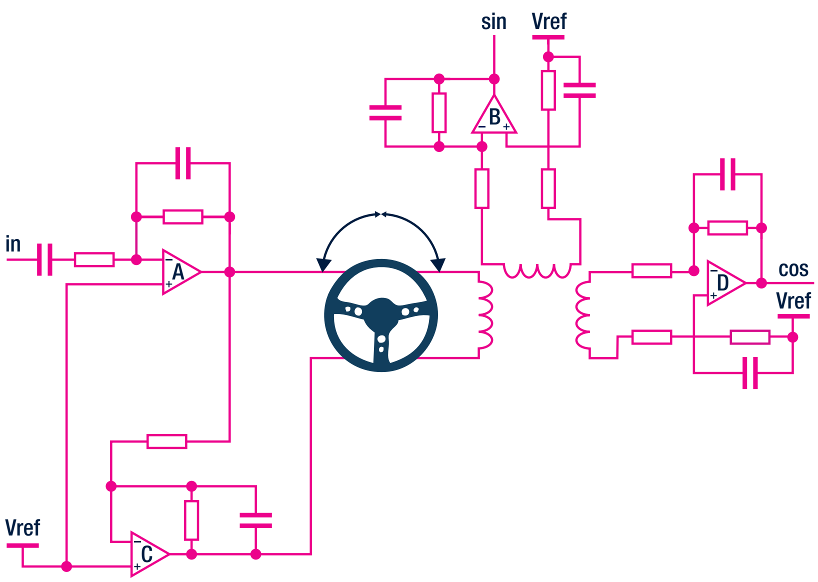


FEATURED PRODUCTS:
- TSU series
- TSZ series

KEY PARAMETERS
- Precision
- Low input bias current
- Low power
- Small package

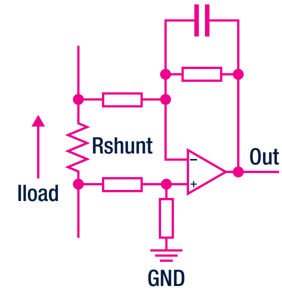
SIGNAL CONDITIONING FOR AUTOMOTIVE CONTROL AND MONITORING

Steering angle sensor



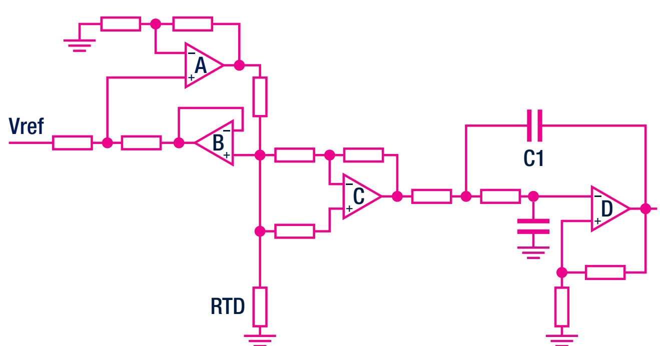
FEATURED PRODUCTS:
- TSX564IYPT
- TSX922IYDT
- TSB582IYDT
- TSB514IYPT

Current measurement



FEATURED PRODUCTS:
- TSV7 series
- TSZ series
- TSX7 series
- TSX9 series

Resistance temperature detector

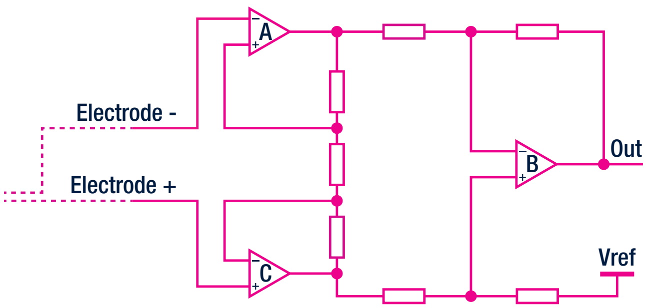


FEATURED PRODUCTS:
- TSZ124IYPT

KEY PARAMETERS
- Precision
- Low power
- Speed
- High voltage
- Specific production flow

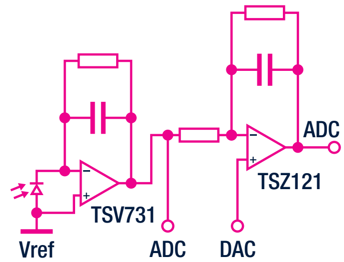
SIGNAL CONDITIONING FOR REMOTE HEALTH MONITORING AND MANAGEMENT

Electrocardiography (ECG)



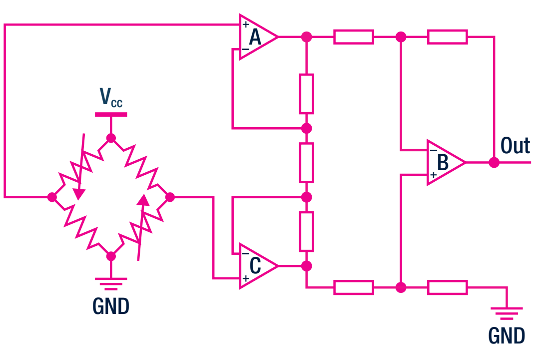
FEATURED PRODUCTS:
- TSZ series

Pulse oximeter sensor



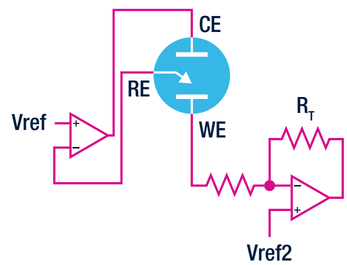
FEATURED PRODUCTS:
- TSZ series
- TSV7 series

Blood pressure sensor



FEATURED PRODUCTS:
- TSV7 series
- TSZ series

Glucose meter

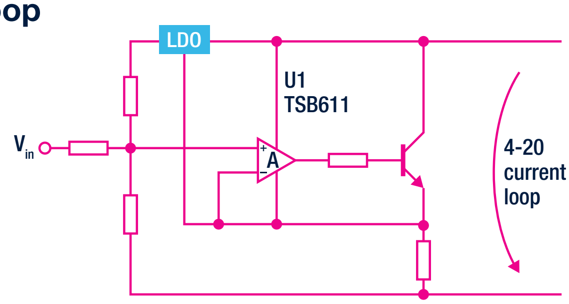


FEATURED PRODUCTS:
- TSV6 series
- TSV7 series

KEY PARAMETERS
- Precision
- Low input bias current
- Low power
- Small package

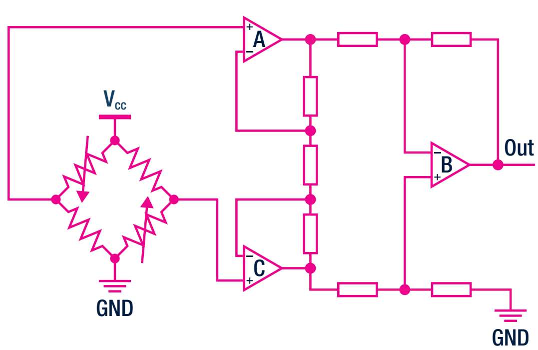
SIGNAL CONDITIONING FOR INDUSTRIAL PROCESS CONTROL AND MONITORING

4-20 mA current loop



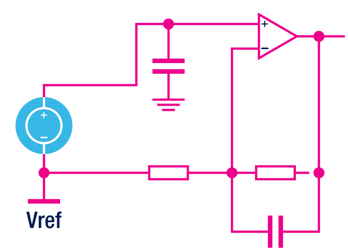
FEATURED PRODUCTS:
- TSB5 series
- TSB6 series
- TSX7 series

Force/pressure (strain gauge)



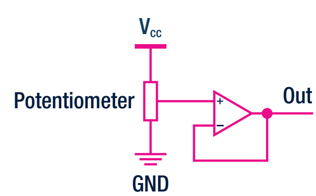
FEATURED PRODUCTS:
- TSZ124IYPT

Thermopile



FEATURED PRODUCTS:
- TSZ series

Potentiometer



FEATURED PRODUCTS:
- TSV6 series
- TSX7 series

KEY PARAMETERS
- Precision
- Low power
- High voltage
- Small package

Operational amplifiers

LOW POWER

TSU11 series: nanopower for battery-powered and energy-harvesting applications

The **TSU11** series operational amplifiers provide an extremely low power consumption per channel of 900 nA typical and 1.2 µA maximum, when supplied by 3.3 V.

The TSU111, TSU112, and the TSU114 can be powered by a coin-type lithium battery or a regulated voltage in low-power applications, as they have a supply voltage range of 1.5 to 5.5 V.

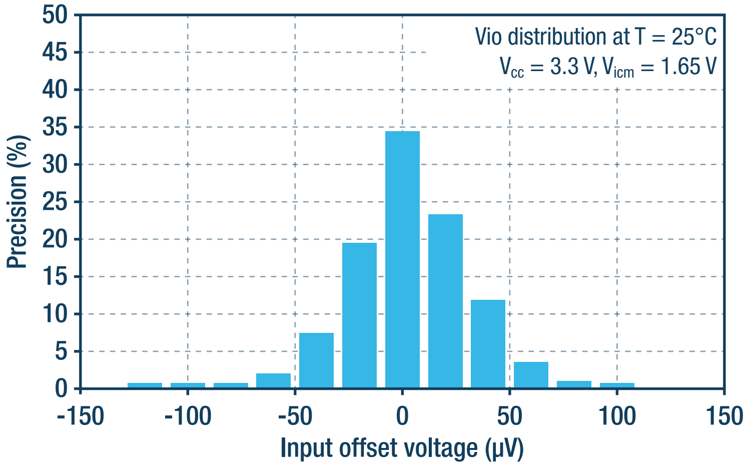
FEATURES

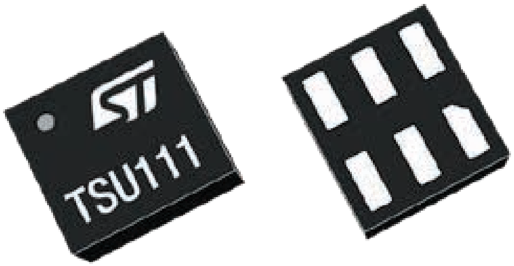
- 900 nA per channel at 25°C
- Low offset voltage:
  - 150 µV (maximum) at 25°C
  - 235 µV (maximum) vs. T
- Low supply voltage: 1.5 to 5.5 V
- Rail-to-rail input and output
- Gain bandwidth product: 11.5 kHz

APPLICATIONS

- PIR and gas sensors: CO, O_2, and H_2S
- Signal conditioning for energy harvesting
- Battery current sensing
- Active RFID tags
- Alarms: PIR sensors

Input offset voltage distribution





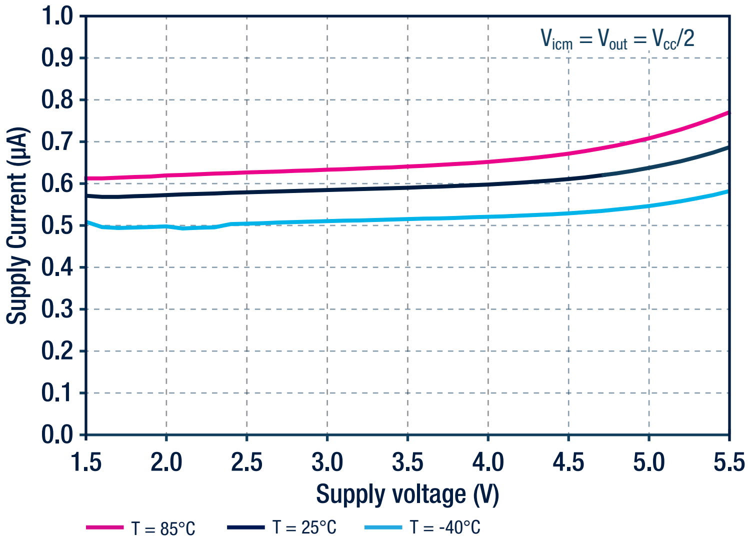
TSU10 series: nanopower (580 nA), rail-to-rail input and output, 5 V CMOS

The **TSU101**, **TSU102**, and **TSU104** operational amplifiers have an ultra-low power consumption of 580 nA typical and 750 nA maximum per channel when powered by 1.8 V.

These amplifiers can be efficiently powered by a coin-type lithium battery or a regulated voltage in low-power applications, as they have a supply voltage range of 1.5 to 5.5 V.

With their 8 kHz gain bandwidth, they are ideal for sensor signal conditioning, as well as battery-supplied and portable applications.

Supply current vs. supply voltage

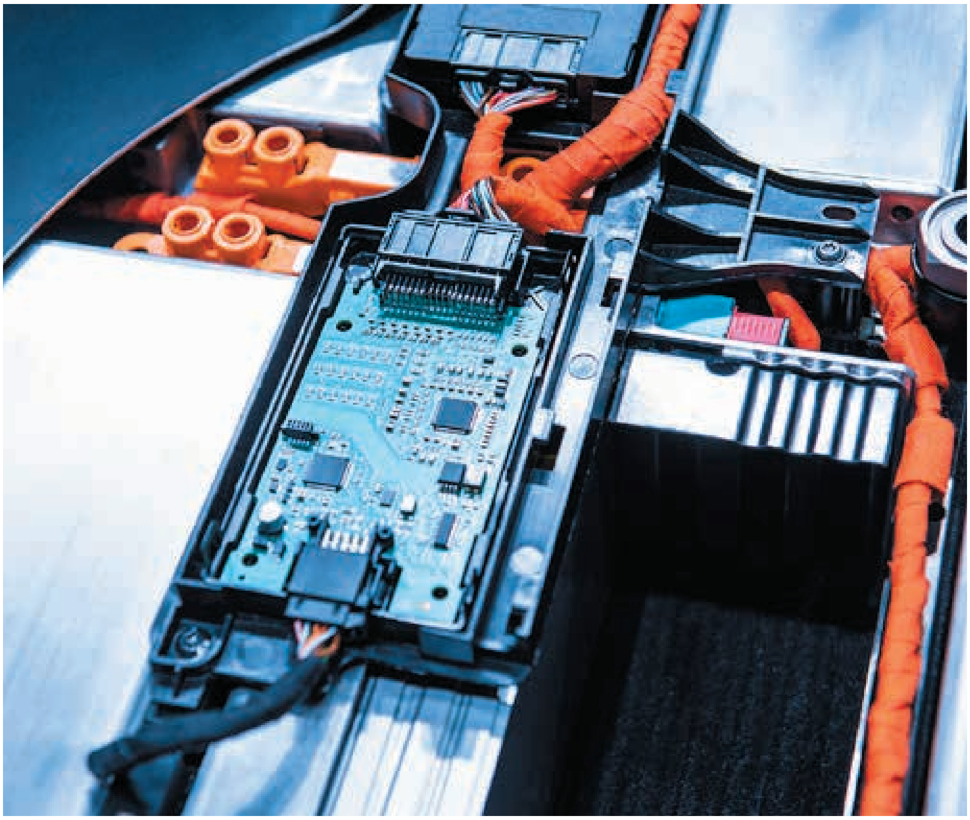


FEATURES

- 580 nA (typical) per channel at 25°C
- Low supply voltage: 1.5 to 5.5 V
- Rail-to-rail input and output
- Gain bandwidth product: 8 kHz
- Low input bias current: 5 pA (maximum) at 25°C

APPLICATIONS

- Ultra-long-life battery-powered applications
- Power metering
- UV and photo sensors



Part number	Typ. I_{CC} per channel (µA)	Min. V_{CC} (V)	Max. V_{CC} (V)	Typ. GBP (MHz)	Typ. SR (V/µs)	Max. V_{IO} @ 25°C (µV)	Rail-to-rail		Single	Dual	Quad	Automotive grade
							In	Out				
Nanopower ($I_{CC} \leq 1$ µA)												
TSU101/2/4	0.58	1.5	5.5	0.008	0.003	3000	Yes	Yes	•	•	•	
TSU111/2/4	0.9	1.5	5.5	0.0115	0.0027	150	Yes	Yes	•	•	•	
TSU111IY/TSU112IY	0.92	1.5	5.5	0.009	0.003	150	Yes	Yes	•	•		✓
Micropower (1 µA < $I_{CC} \leq 35$ µA)												
TS941/2/4	1.2	2.5	10	0.01	0.0045	10000	No	Yes	•	•	•	
TS941A/2A/4A	1.2	2.5	10	0.01	0.0045	5000	No	Yes	•	•	•	
TSV611/2	10	1.5	5.5	0.12	0.04	4500	Yes	Yes	•	•		
TSV611A/2A	10	1.5	5.5	0.12	0.04	800	Yes	Yes	•	•		
TSV6191/2	10	1.5	5.5	0.45	0.08	4500	Yes	Yes	•	•		
TSV6191A/2A	10	1.5	5.5	0.45	0.08	800	Yes	Yes	•	•		
TSV711/2/4	10	1.5	5.5	0.12	0.06	200	Yes	Yes	•	•	•	
TS931/2/4	20	2.7	10	0.1	0.05	10000	No	Yes	•	•	•	
TS931A/4A	20	2.7	10	0.1	0.05	5000	No	Yes	•		•	
TSV621/2/4	29	1.5	5.5	0.42	0.14	4000	Yes	Yes	•	•	•	
TSV621A/2A/4A	29	1.5	5.5	0.42	0.14	800	Yes	Yes	•	•	•	
TSV6291/2/4	29	1.5	5.5	1.3	0.5	4000	Yes	Yes	•	•	•	
TSV6291A/2A/4A	29	1.5	5.5	1.3	0.5	800	Yes	Yes	•	•	•	
TSZ121/2/4	31	1.8	5.5	0.4	0.19	5	Yes	Yes	•	•	•	✓
Low power (35 µA < I_{CC} < 1 mA)												
TSV521/2/4	45	2.7	5.5	1.15	0.89	1000	Yes	Yes	•	•	•	
TSV521A/2A/4A	45	2.7	5.5	1.15	0.89	600	Yes	Yes	•	•	•	
TSX631/2/4	45	3.3	16	0.2	0.12	1000	Yes	Yes	•	•	•	✓
TSX631A/2A/4A	45	3.3	16	0.2	0.12	500	Yes	Yes	•	•	•	✓
TSV631/2/4	60	1.5	5.5	0.88	0.34	3000	Yes	Yes	•	•	•	✓
TSV631A/2A/4A	60	1.5	5.5	0.88	0.34	500	Yes	Yes	•	•	•	
TSV6391/2/4	60	1.5	5.5	2.4	1.1	3000	Yes	Yes	•	•	•	
TSV6391A/2A/4A	60	1.5	5.5	2.4	1.1	500	Yes	Yes	•	•	•	
TSV731/2/4	60	1.5	5.5	0.9	0.35	200	Yes	Yes	•	•	•	
TSB611/TSB612	103	2.7	36	0.56	0.18	1000	No	Yes	•			✓
LMV321L/358L/324L	130	2.7	5.5	1.3	0.7	7000	No	Yes	•	•	•	
LMV321/358/324	145	2.7	6	1	0.35	3000	Yes	Yes	•	•	•	✓
TS1851/2/4	165	1.8	6	0.65	0.25	3000	Yes	Yes	•	•	•	
LMX321/358/324	180	2.5	5.5	1.3	0.7	4000	No	Yes	•	•	•	
TSV851/2/4	180	2.3	5.5	1.3	0.7	4000	No	Yes	•	•	•	✓
TSV851A/2A/4A	180	2.3	5.5	1.3	0.7	800	No	Yes	•	•	•	✓
TSZ151	210	1.8	5.5	1.6	0.8	7	Yes	Yes	•			✓
TSX561/2/4	250	3	16	0.9	1.1	1000	Yes	Yes	•	•	•	✓
TSX561A/2A/4A	250	3	16	0.9	1.1	600	Yes	Yes	•	•	•	✓
LMV821/2/4	300	2.5	5.5	5.5	1.9	3500	No	Yes	•	•	•	✓

Part number	Typ. I_{CC} per channel (µA)	Min. V_{CC} (V)	Max. V_{CC} (V)	Typ. GBP (MHz)	Typ. SR (V/µs)	Max. V_{IO} @ 25°C (µV)	Rail-to-rail		Single	Dual	Quad	Automotive grade
							In	Out				
Low power (35 µA < I_{CC} < 1 mA)												
TSB571/TSB572	380	4	36	2.5	1	1500	Yes	Yes	•	•		✓
TS1871/2/4	400	1.8	6	1.8	0.6	3000	Yes	Yes	•	•	•	✓
TS1871A/2A/4A	400	1.8	6	1.8	0.6	1000	Yes	Yes	•	•	•	✓
TS912/4	400	2.7	16	1.4	1	10000	Yes	Yes		•	•	✓
TS912A/4A	400	2.7	16	1.4	1	5000	Yes	Yes		•	•	✓
LMC6482	500	2.7	16	2.7	1.4	2000	Yes	Yes		•		
TS512/4	500	6	30	3	1.5	2500	No	No		•	•	✓
TSV321/358/324	500	2.5	6	1.4	0.6	3000	Yes	Yes	•	•	•	✓
TSX711/2	660	2.7	16	2.7	1.3	200	Yes	Yes	•	•		✓
TSX711A	660	2.7	16	2.5	1.5	100	Yes	Yes	•			✓
TSX7191/2	660	2.7	16	9	2.3	200	Yes	Yes	•	•		✓
TSX7191A	660	2.7	16	9	2.3	100	Yes	Yes	•			✓
TSV911/2/4	780	2.5	5.5	8	4.5	4500	Yes	Yes	•	•	•	✓
TSV911A/2A/4A	780	2.5	5.5	8	4.5	1500	Yes	Yes	•	•	•	✓
TSV912H	780	2.5	5.5	8	4.5	4500	Yes	Yes		•		✓
TSZ181/182	800	2.2	5.5	3	4.7	25	Yes	Yes	•	•		✓
TSZ181H/182H	800	2.2	5.5	3	4.7	25	Yes	Yes	•	•		✓
TSZ181H1/182H1	800	2.2	5.5	3	4.7	70	Yes	Yes	•	•		✓
TSV991/2/4	820	2.5	5.5	20	10	4500	Yes	Yes	•	•	•	✓
TSV991A/2A/4A	820	2.5	5.5	20	10	1500	Yes	Yes	•	•	•	✓
TS507	850	2.7	5.5	1.9	0.6	100	Yes	Yes	•			✓
TS9222/4	900	2.7	12	4	1.3	500	Yes	Yes		•	•	✓
TS951/952/954	900	2.7	12	3	1	6000	Yes	Yes	•	•	•	✓
TS9511	950	2.7	12	3	1	800	Yes	Yes	•			✓
Amplifiers with standby pin												
TSV620/3/5	29	1.5	5.5	0.42	0.14	4000	Yes	Yes	•	•	•	
TSV620A/3A	29	1.5	5.5	0.42	0.14	800	Yes	Yes	•	•		
TSV6290/3	29	1.5	5.5	1.3	0.5	4000	Yes	Yes	•	•		
TSV6290A/3A	29	1.5	5.5	1.3	0.5	800	Yes	Yes	•	•		
TSV630/3/5	60	1.5	5.5	0.88	0.34	3000	Yes	Yes	•	•	•	
TSV630A/3A/5A	60	1.5	5.5	0.88	0.34	500	Yes	Yes	•	•	•	
TSV6390/3/5	60	1.5	5.5	2.4	1.1	3000	Yes	Yes	•	•	•	
TSV6390A/3A	60	1.5	5.5	2.4	1.1	500	Yes	Yes	•	•		
TSV850/3	180	2.3	5.5	1.3	0.7	4000	No	Yes	•	•		
TSV850A/3A	180	2.3	5.5	1.3	0.7	800	No	Yes	•	•		
LMV820/3	300	2.5	5.5	5.5	1.9	3500	No	Yes	•	•		
LMV820A/3A	300	2.5	5.5	5.5	1.9	800	No	Yes	•	•		

Any non-automotive product may be eligible for AEC-Q100 qualification. Contact ST Sales representative for additional information.

PRECISION

TSZ181/2: very high accuracy, Vio ≤ 25 µV, zero-drift 5 V

The **TSZ18** series operational amplifiers are available in single- and dual-channel versions. They have extremely low offset voltages and virtually zero-drift when subjected to temperature changes. These devices offer rail-to-rail input and output, an excellent speed-to-power consumption ratio, and a 3 MHz gain bandwidth product while consuming only 1 mA at 5 V. They also feature an ultra-low input bias current. These characteristics make this series particularly well-suited for high-accuracy, high-bandwidth sensors.

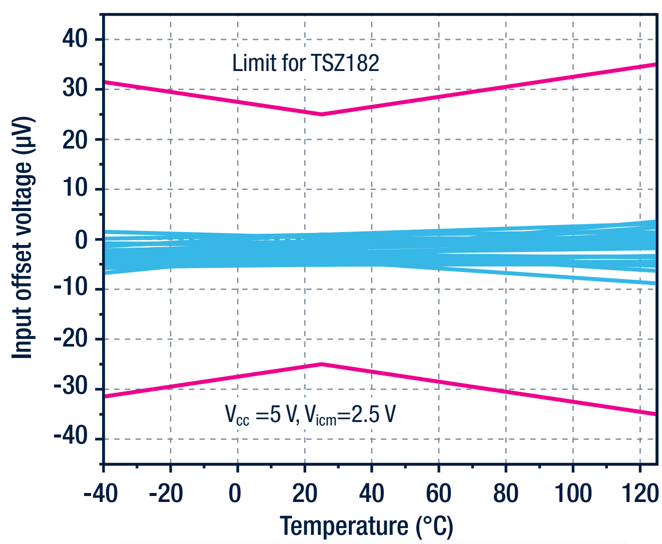
FEATURES

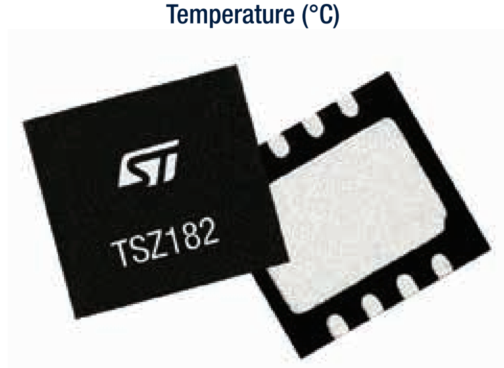
- Very high accuracy and stability:
  - 25 µV max at 25°C
  - 35 µV -40 to 125°C
- Gain bandwidth product: 3 MHz
- Rail-to-rail input and output
- Low supply voltage: 2.2 - 5.5 V
- Low power consumption: 1 mA max. at 5 V

APPLICATIONS

- High accuracy signal conditioning
- Automotive current measurement
- Battery-powered instrumentation

Input offset voltage vs. temperature





DFN8

TSZ151: very high accuracy (7 µV) high bandwidth (1.6 MHz) zero-drift 5 V

The **TSZ151** is a single-channel operational amplifier that provides very low offset voltages with almost zero-drift in response to temperature changes. It has rail-to-rail input and output, a great speed/power consumption ratio, and a gain bandwidth product of 1.6 MHz, while consuming a mere 210 µA at 5 V. Additionally, the device boasts an ultra-low input bias current, making it perfect for high-accuracy sensor interfaces.

FEATURES

- Very high accuracy and stability: offset voltage
- -7 µV max. at 25°C
- -10 µV over full temperature range (-40°C to 125°C)
- Rail-to-rail input and output
- Low supply voltage: from 1.8 to 5.5 V
- Low power consumption: 210 µA at 5 V
- Gain bandwidth product: 1.6 MHz
- Extended temperature range: -40 to 125°C
- AEC-Q100 qualified

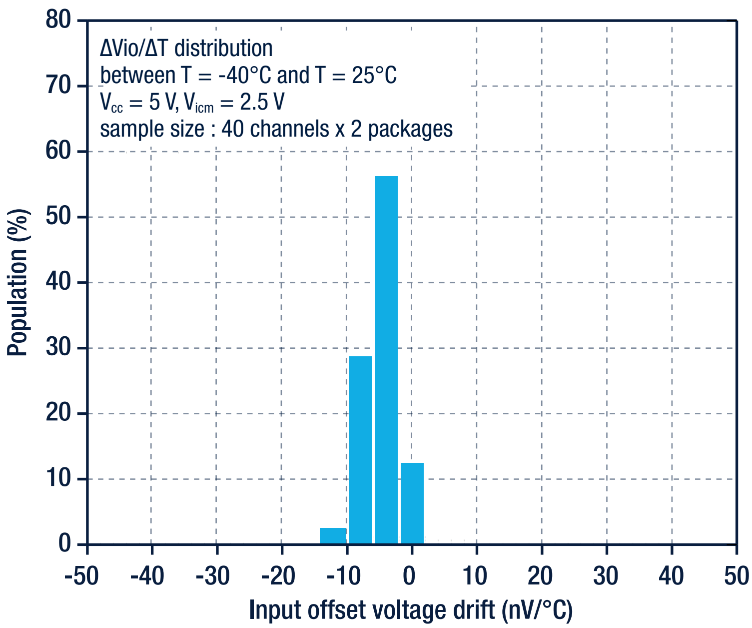
BENEFITS

- Higher accuracy without calibration
- Accuracy is virtually unaffected by temperature change

APPLICATIONS

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

Input offset voltage temperature drift distribution at V_{cc}= 5 V (-40°C to 25°C)



SOT23-5L

SC70-5

Part number	Max. V_{IO} @ 25°C (µV)	Typ. V_{IO} drift (µV/°C)	Max. Iib @ 25°C (pA)	Min. V_{CC} (V)	Max. V_{CC} (V)	Typ. GBP (MHz)	Typ. SR (V/µs)	Typ. I_{CC} per channel (µA)	Typ. 1 kHz noise (nV/√Hz)	Rail-to-rail		Single	Dual	Quad	Automotive grade
										In	Out				
Low input offset															
TSZ121/2/4	5	0.01	200	1.8	5.5	0.4	0.19	31	37	Yes	Yes	•	•	•	✓
TSZ151	7	0.012	200	1.8	5.5	1.3	0.8	210	27	Yes	Yes	•			✓
TSZ181/182	25	0.01	200	2.2	5.5	3	4.7	800	37	Yes	Yes	•	•		✓
TSX711A	100	0.8	50	2.7	16	2.5	1.5	660	20	Yes	Yes	•			✓
TS507	100	1	70000	2.7	5.5	1.9	0.6	850	12	Yes	Yes	•			✓
TSU111/2/4	150	0.5	5	1.5	5.5	0.0115	0.0027	0.9	265	Yes	Yes	•	•	•	
TSX711/2	200	0.8	50	2.7	16	2.7	1.3	660	22	Yes	Yes	•	•		✓
TSX7191/1A/2	200	0.8	50	2.7	16	9	2.3	660	22	Yes	Yes	•	•		✓
TSV731/2/4	200	2	10	1.5	5.5	0.9	0.35	60	35	Yes	Yes	•	•	•	
TSV711/2/4	200	3	10	1.5	5.5	0.12	0.06	10	100	Yes	Yes	•	•	•	
TSV7721/2/3	200	1	2	1.8	5.5	22	11	1.7	13	No	Yes	•	•		✓
TSV771/2/4	200	1	2	2.0	5.5	20	13	1.9	13	Yes	Yes	•	•	•	✓
TSV781/2	200	1	2	2.0	5.5	30	20	3.3	14	Yes	Yes	•	•		✓
TSV791/2/4	200	1	2.2	2.2	5.5	50	30	5.5	6.5	Yes	Yes	•	•	•	✓
TSB711A/TSB712A	300	1	900000	2.7	36	6	3	1800	12	Yes	Yes	•	•		✓
TSB7191A/TSB7192A	300	1	900000	2.7	36	22	12	1800	12	Yes	Yes	•	•		✓
TSX631A/2A/4A	500	1	100	3.3	16	0.2	0.12	45	60	Yes	Yes	•	•	•	✓
TS9222/4	500	2	55000	2.7	12	4	1.3	900	9	Yes	Yes		•	•	✓
TSV630A/3A/5A	500	2	10	1.5	5.5	0.88	0.34	60	60	Yes	Yes	•	•	•	
TSV631A/2A/4A	500	2	10	1.5	5.5	0.88	0.34	60	60	Yes	Yes	•	•	•	
TSV6390A/3A	500	2	10	1.5	5.5	2.4	1.1	60	60	Yes	Yes	•	•		
TSV6391A/2A/4A	500	2	10	1.5	5.5	2.4	1.1	60	60	Yes	Yes	•	•	•	
TSV521A/2A/4A	600	2	10	2.7	5.5	1.15	0.89	45	57	Yes	Yes	•	•	•	
TSX561A/2A/4A	600	2	100	3	16	0.9	1.1	250	48	Yes	Yes	•	•	•	✓
LMV820A/3A	800	1	120000	2.5	5.5	5.5	1.9	300	16	No	Yes	•	•		
LMV821A/2A/4A	800	1	120000	2.5	5.5	5.5	1.9	300	16	No	Yes	•	•	•	✓
TSV850A/3A	800	1	60000	2.3	5.5	1.3	0.7	180	39	No	Yes	•	•		
TSV851A/2A/4A	800	1	60000	2.3	5.5	1.3	0.7	180	39	No	Yes	•	•	•	✓
TS9511	800	2	70000	2.7	12	3	1	950	25	Yes	Yes	•			✓
TSV611A/2A	800	2	10	1.5	5.5	0.12	0.04	10	105	Yes	Yes	•	•		
TSV6191A/2A	800	2	10	1.5	5.5	0.45	0.08	10	105	Yes	Yes	•	•		
TSV620A/3A	800	2	10	1.5	5.5	0.42	0.14	29	70	Yes	Yes	•	•		
TSV621A/2A/4A	800	2	10	1.5	5.5	0.42	0.14	29	70	Yes	Yes	•	•	•	
TSV6290A/3A	800	2	10	1.5	5.5	1.3	0.5	29	70	Yes	Yes	•	•		
TSV6291A/2A/4A	800	2	10	1.5	5.5	1.3	0.5	29	70	Yes	Yes	•	•	•	
TSB711/TSB712	800	1	900000	2.7	36	6	3	1800	12	Yes	Yes	•	•		✓
TSB7191/TSB7192	800	1	900000	2.7	36	22	12	1800	12	Yes	Yes	•	•		✓

Any non-automotive product may be eligible for AEC-Q100 qualification. Contact ST Sales representative for additional information.

LOW INPUT BIAS CURRENT

TSX71 series: 2.7–16 V CMOS rail-to-rail 200 µV precision amplifiers

The **TSX71** series of operational amplifiers provides high precision performance with a low input offset voltage of up to 200 µV at 25°C. These amplifiers have rail-to-rail input and output functionality, which allows them to be used with a full range of inputs and outputs without any limitations. This feature is particularly useful for low-voltage supplies, such as the 2.7 V that the TSX71 can operate with. The TSX71 series has the significant advantage of offering a wide range of supply voltages, from 2.7 to 16 V. These amplifiers are ideal for signal conditioning in sensor interface applications due to their low input bias current performance. Additionally, the rail-to-rail functionality, high ESD tolerance (4 kV HBM), and wide temperature range make them suitable for use in automotive applications.

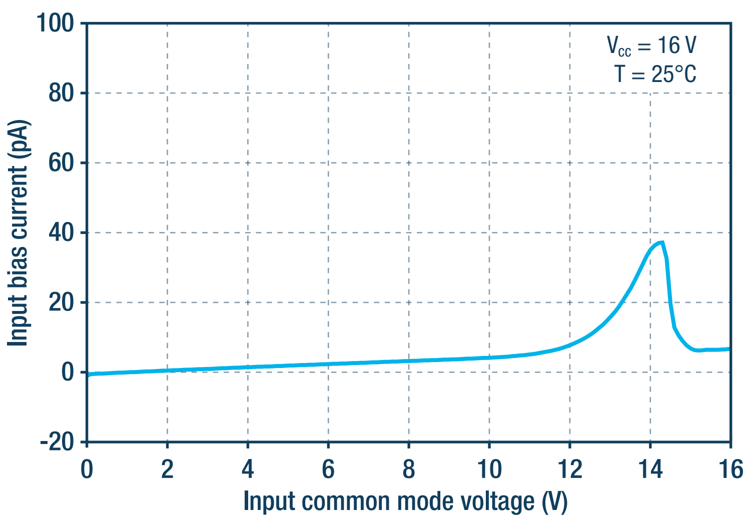
FEATURES

- Low input offset voltage: 200 µV (max.)
- Rail-to-rail input and output
- Low current consumption: 800 µA (max.)
- Gain bandwidth product 2.7 MHz (unity gain stable) or 9 MHz (stable for gain > 10)
- Low supply voltage: 2.7 to 16 V
- Low input bias current: 50 pA (max.)
- High ESD tolerance: 4 kV HBM
- AEC-Q100 qualified

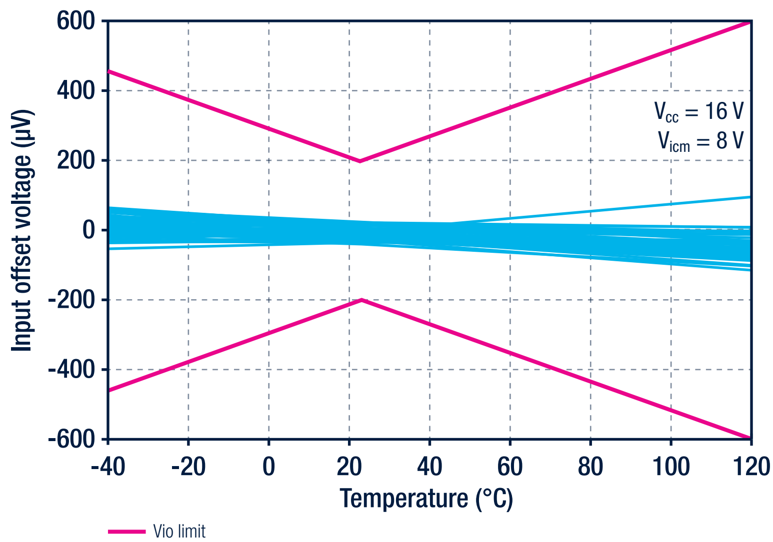
APPLICATIONS

- Battery-powered instrumentation
- Instrumentation amplifiers
- Active filtering
- DAC buffers
- High-impedance sensor interfaces
- Current sensing (high- and low-side)
- Automotive

Input common-mode voltage (V)



Input offset voltage vs. temperature at V_{cc} = 16 V



Part number	Max. Iib @ 25°C (pA)	Max. V_{io} @ 25°C (µV)	Min. V_{CC} (V)	Max. V_{CC} (V)	Typ. GBP (MHz)	Typ. SR (V/µs)	Typ. I_{CC} per channel (µA)	Typ. 1 kHz noise (nV/√Hz)	Rail-to-rail		Single	Dual	Quad	Automotive grade
									In	Out				
Low input bias current														
TSU111IY/12IY	2	150	1.5	5.5	0.009	0.003	0.92	200	Yes	Yes	•	•		✓
TSV771/2/4	2	200	2	5.5	20	13	1800	13	Yes	Yes	•	•	•	✓
TSV7721/2/3	2	200	1.8	5.5	22	11	1700	7	No	Yes	•	•		✓
TSV781/2	2	400/200	2	5.5	30	20	3300	14	Yes	Yes	•	•		✓
TSV791/2/4	2	200	2.2	5.5	50	30	5300	6.5	Yes	Yes	•	•	•	✓
TSU101/2/4	5	3000	1.5	5.5	0.008	0.003	0.58	265	Yes	Yes	•	•	•	
TSU111/2/4	5	150	1.5	5.5	0.0115	0.0027	0.9	265	Yes	Yes	•	•	•	
TSV521/2/4	10	1000	2.7	5.5	1.15	0.89	45	57	Yes	Yes	•	•	•	
TSV521A/2A/4A	10	600	2.7	5.5	1.15	0.89	45	57	Yes	Yes	•	•	•	
TSV611/2	10	4500	1.5	5.5	0.12	0.04	10	105	Yes	Yes	•	•		
TSV611A/2A	10	800	1.5	5.5	0.12	0.04	10	105	Yes	Yes	•	•		
TSV6191/2	10	4500	1.5	5.5	0.45	0.08	10	105	Yes	Yes	•	•		
TSV6191A/2A	10	800	1.5	5.5	0.45	0.08	10	105	Yes	Yes	•	•		
TSV620/3/5	10	4000	1.5	5.5	0.42	0.14	29	70	Yes	Yes	•	•	•	
TSV620A/3A	10	800	1.5	5.5	0.42	0.14	29	70	Yes	Yes	•	•		
TSV621/2/4	10	4000	1.5	5.5	0.42	0.14	29	70	Yes	Yes	•	•	•	
TSV621A/2A/4A	10	800	1.5	5.5	0.42	0.14	29	70	Yes	Yes	•	•	•	
TSV6290/3	10	4000	1.5	5.5	1.3	0.5	29	70	Yes	Yes	•	•		
TSV6290A/3A	10	800	1.5	5.5	1.3	0.5	29	70	Yes	Yes	•	•		
TSV6291/2/4	10	4000	1.5	5.5	1.3	0.5	29	70	Yes	Yes	•	•	•	
TSV6291A/2A/4A	10	800	1.5	5.5	1.3	0.5	29	70	Yes	Yes	•	•	•	
TSV630/3/5	10	3000	1.5	5.5	0.88	0.34	60	60	Yes	Yes	•	•	•	
TSV630A/3A/5A	10	500	1.5	5.5	0.88	0.34	60	60	Yes	Yes	•	•	•	
TSV631/2/4	10	3000	1.5	5.5	0.88	0.34	60	60	Yes	Yes	•	•	•	✓
TSV631A/2A/4A	10	500	1.5	5.5	0.88	0.34	60	60	Yes	Yes	•	•	•	
TSV6390/3/5	10	3000	1.5	5.5	2.4	1.1	60	60	Yes	Yes	•	•	•	
TSV6390A/3A	10	500	1.5	5.5	2.4	1.1	60	60	Yes	Yes	•	•		
TSV6391/2/4	10	3000	1.5	5.5	2.4	1.1	60	60	Yes	Yes	•	•	•	
TSV6391A/2A/4A	10	500	1.5	5.5	2.4	1.1	60	60	Yes	Yes	•	•	•	
TSV711/2/4	10	200	1.5	5.5	0.12	0.06	10	100	Yes	Yes	•	•	•	
TSV731/2/4	10	200	1.5	5.5	0.9	0.35	60	35	Yes	Yes	•	•	•	
TSV911/2/4	10	4500	2.5	5.5	8	4.5	780	27	Yes	Yes	•	•	•	✓
TSV911A/2A/4A	10	1500	2.5	5.5	8	4.5	780	27	Yes	Yes	•	•	•	✓
TSV912H	10	4500	2.5	5.5	8	4.5	780	27	Yes	Yes		•		✓
TSV991/2/4	10	4500	2.5	5.5	20	10	820	27	Yes	Yes	•	•	•	✓
TSV991A/2A/4A	10	1500	2.5	5.5	20	10	820	27	Yes	Yes	•	•	•	✓
LMC6482	50	2000	2.7	16	2.7	1.4	500	22	Yes	Yes		•		
TSX711/2	50	200	2.7	16	2.7	1.3	660	22	Yes	Yes	•	•		✓
TSX711A	50	100	2.7	16	2.5	1.5	660	20	Yes	Yes	•			✓
TSX7191/2	50	200	2.7	16	9	2.3	660	22	Yes	Yes	•	•		✓
TSX7191A	50	100	2.7	16	9	2.3	660	22	Yes	Yes	•			✓
TSX561/2/4	100	1000	3	16	0.9	1.1	250	48	Yes	Yes	•	•	•	✓
TSX561A/2A/4A	100	600	3	16	0.9	1.1	250	48	Yes	Yes	•	•	•	✓
TSX631/2/4	100	1000	3.3	16	0.2	0.12	45	60	Yes	Yes	•	•	•	✓
TSX631A/2A/4A	100	500	3.3	16	0.2	0.12	45	60	Yes	Yes	•	•	•	✓
TSX920/923	100	4000	4	16	10	17.2	2800	16.5	Yes	Yes	•	•		
TSX921/922	100	4000	4	16	10	17.2	2800	16.5	Yes	Yes	•	•		✓
TSX9291/TSX9292	100	4000	4	16	16	26	2800	16.5	Yes	Yes	•	•		✓
TS912/4	150	10000	2.7	16	1.4	1	400	30	Yes	Yes		•	•	✓
TS912A/4A	150	5000	2.7	16	1.4	1	400	30	Yes	Yes		•	•	✓
TS931/2/4	150	10000	2.7	10	0.1	0.05	20	76	No	Yes	•	•	•	
TS931A/4A	150	5000	2.7	10	0.1	0.05	20	76	No	Yes	•		•	
TS941/2/4	150	10000	2.5	10	0.01	0.0045	1.2	330	No	Yes	•	•	•	
TS941A/2A/4A	150	5000	2.5	10	0.01	0.0045	1.2	330	No	Yes	•	•	•	
TSZ121/2/4	200	5	1.8	5.5	0.4	0.19	31	37	Yes	Yes	•	•	•	✓
TSZ181/182	200	25	2.2	5.5	3	4.7	800	37	Yes	Yes	•	•		✓
TSZ151	200	7	1.8	5.5	1.3	0.8	300	27	Yes	Yes	•			✓

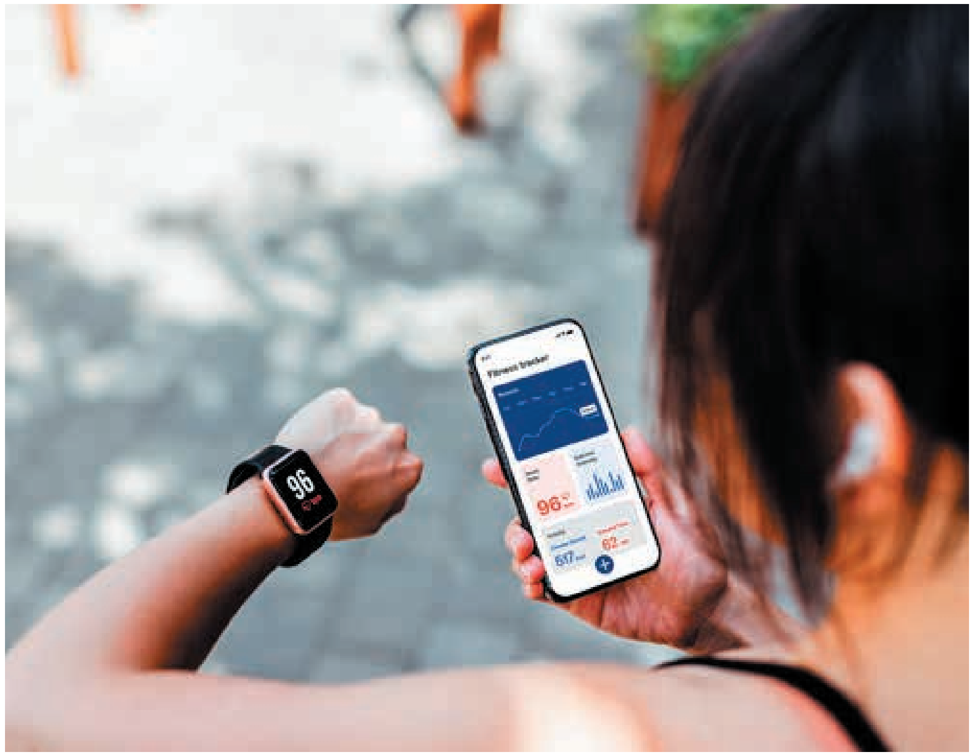
Any non-automotive product may be eligible for AEC-Q100 qualification. Contact ST Sales representative for additional information.

LOW V_{CC} MIN

TSV611/2: CMOS amplifiers, rail-to-rail input and output, 5 V low-power

The **TSV611**, and **TSV612** operational amplifiers are designed for low-voltage, low-power operation with rail-to-rail input and output. Available in single- and dual-channel options, they feature an ultra-low input bias current and low input offset voltage. These devices have a gain bandwidth product of 120 kHz while consuming only 10 µA at 5 V. They are also able to operate at very low supply voltage levels, down to 1.5 V.

These characteristics make them perfect choice for battery-powered and portable applications, sensor interfaces, and active filtering.



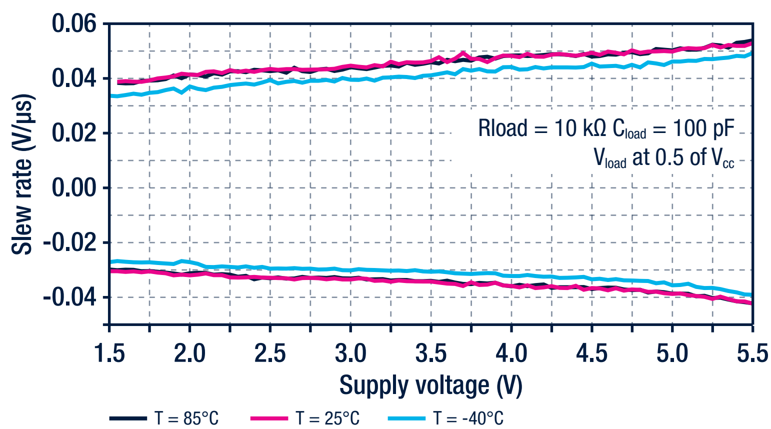
FEATURES

- Low input bias current: 1 pA (typ.)
- Low input offset voltage: 800 µV (max.) A version
- Rail-to-rail input and output
- Low supply voltage: 1.5 to 5.5 V
- Low power consumption: 10 µA (typ.) at 5 V
- Industrial temperature range: -40 to +85°C
- Gain bandwidth product: 120 kHz (typ.)

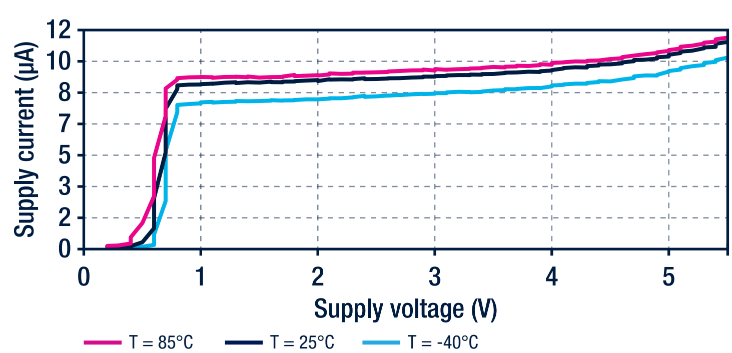
APPLICATIONS

- Battery-powered applications
- Smoke detectors
- Proximity sensors
- Portable devices
- Signal conditioning
- Active filtering
- Medical instrumentation

Slew rate vs. supply voltage



Supply current vs. supply voltage at $V_{icm} = V_{cc}/2$



Part number	Min. V_{CC} (V)	Max. V_{CC} (V)	Typ. GBP (MHz)	Typ. SR (v/µs)	Typ. I_{CC} per channel (µA)	Max. V_{IO} @ 25°C (µV)	Max. Iib @ 25°C (pA)	Typ. 1 kHz noise (nV/√Hz)	Typ. I_{OUT} (mA)	Rail-to-rail		Single	Dual	Quad	Automotive grade
										In	Out				
Low voltage (V_{CC} min. ≤ 2.2 V)															
TSU101/2/4	1.5	5.5	0.008	0.003	0.58	3000	5	265	5	Yes	Yes	•	•	•	
TSU111/2/4	1.5	5.5	0.0115	0.0027	0.9	150	5	265	41	Yes	Yes	•	•	•	
TSU111IY/12IY	1.5	5.5	0.009	0.003	0.92	150	2	200	22	Yes	Yes	•	•		✓
TSV611/2	1.5	5.5	0.12	0.04	10	4500	10	105	60	Yes	Yes	•	•		
TSV611A/2A	1.5	5.5	0.12	0.04	10	800	10	105	60	Yes	Yes	•	•		
TSV6191/2	1.5	5.5	0.45	0.08	10	4500	10	105	60	Yes	Yes	•	•		
TSV6191A/2A	1.5	5.5	0.45	0.08	10	800	10	105	60	Yes	Yes	•	•		
TSV620/3/5	1.5	5.5	0.42	0.14	29	4000	10	70	69	Yes	Yes	•	•	•	
TSV620A/3A	1.5	5.5	0.42	0.14	29	800	10	70	69	Yes	Yes	•	•		
TSV621/2/4	1.5	5.5	0.42	0.14	29	4000	10	70	69	Yes	Yes	•	•	•	
TSV621A/2A/4A	1.5	5.5	0.42	0.14	29	800	10	70	69	Yes	Yes	•	•	•	
TSV6290/3	1.5	5.5	1.3	0.5	29	4000	10	70	69	Yes	Yes	•	•		
TSV6290A/3A	1.5	5.5	1.3	0.5	29	800	10	70	69	Yes	Yes	•	•		
TSV6291/2/4	1.5	5.5	1.3	0.5	29	4000	10	70	69	Yes	Yes	•	•	•	
TSV6291A/2A/4A	1.5	5.5	1.3	0.5	29	800	10	70	69	Yes	Yes	•	•	•	
TSV630/3/5	1.5	5.5	0.88	0.34	60	3000	10	60	69	Yes	Yes	•	•	•	
TSV630A/3A/5A	1.5	5.5	0.88	0.34	60	500	10	60	69	Yes	Yes	•	•	•	
TSV631/2/4	1.5	5.5	0.88	0.34	60	3000	10	60	69	Yes	Yes	•	•	•	✓
TSV631A/2A/4A	1.5	5.5	0.88	0.34	60	500	10	60	69	Yes	Yes	•	•	•	
TSV6390/3/5	1.5	5.5	2.4	1.1	60	3000	10	60	69	Yes	Yes	•	•	•	
TSV6390A/3A	1.5	5.5	2.4	1.1	60	500	10	60	69	Yes	Yes	•	•		
TSV6391/2/4	1.5	5.5	2.4	1.1	60	3000	10	60	69	Yes	Yes	•	•	•	
TSV6391A/2A/4A	1.5	5.5	2.4	1.1	60	500	10	60	69	Yes	Yes	•	•	•	
TSV711/2/4	1.5	5.5	0.12	0.06	10	200	10	100	45	Yes	Yes	•	•	•	
TSV731/2/4	1.5	5.5	0.9	0.35	60	200	10	35	52	Yes	Yes	•	•	•	
TS1851/2/4	1.8	6	0.65	0.25	165	3000	50000	40	48	Yes	Yes	•	•	•	
TS1871/2/4	1.8	6	1.8	0.6	400	3000	125000	27	72	Yes	Yes	•	•	•	✓
TS1871A/2A/4A	1.8	6	1.8	0.6	400	1000	125000	27	72	Yes	Yes	•	•	•	✓
TSZ121/2/4	1.8	5.5	0.4	0.19	31	5	200	37	17	Yes	Yes	•	•	•	✓
TSZ151	1.8	5.5	1.3	0.8	300	7	200	27	30	Yes	Yes	•			✓
TSV7721/2/3	1.8	5.5	22	11	1700	200	2	7	65	No	Yes	•	•		✓
TSV771/2/4	2	5.5	20	13	1800	200	2	13	65	Yes	Yes	•	•	•	✓
TSV781/2	2	5.5	30	20	3300	200	2	14	60	Yes	Yes	•	•		✓
TSV791/2/4	2.2	5.5	50	30	5300	200	2	6.5	60	Yes	Yes	•	•	•	✓
TSZ181/182	2.2	5.5	3	4.7	800	25	200	37	25	Yes	Yes	•	•		✓

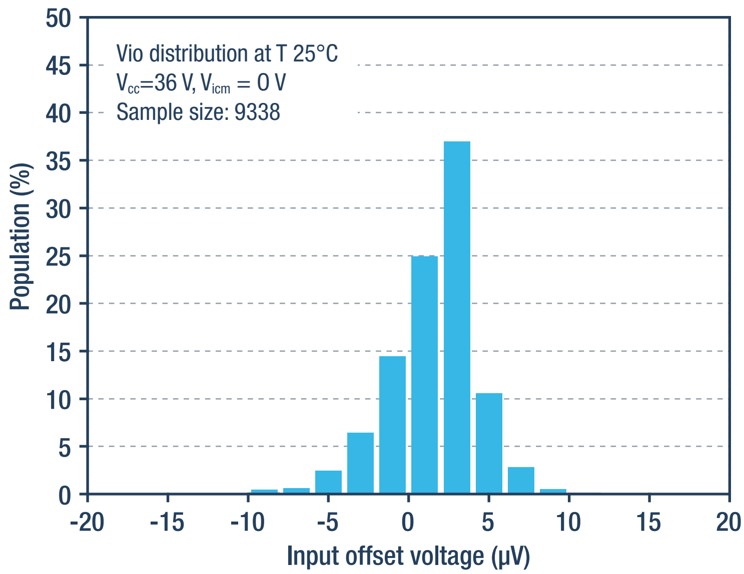
Any non-automotive product may be eligible for AEC-Q100 qualification. Contact ST Sales representative for additional information.

HIGH V_{CC} MAX.

TSB182: very high accuracy (20 µV), zero-drift, rail-to-rail output, 3 MHz, 36 V

The **TSB182** is a dual operational amplifier that provides very high precision with a maximum input-offset voltage of 20 µV. It has an extended supply voltage range and features rail-to-rail output. This amplifier offers an excellent speed/current consumption ratio with a gain bandwidth product of 3 MHz while consuming 650 µA typically per operational amplifier on a large supply voltage range. The TSB182 operates over a wide temperature range from -40 to 125°C, making it ideal for industrial and automotive applications with the associated qualification. Due to its small package size, the TSB182 can be used in applications where board space is limited, reducing the overall cost of the PCB.

Input offset voltage distribution at V_{cc}= 36 V and V_{icm}= 0 V



FEATURES

- Very low offset voltage: 20 µV max. @ 25°C
- Rail-to-rail output
- Wide supply voltage: 4 to 36 V
- Gain bandwidth product: 3 MHz
- Slew rate: 2 V/µs
- Low noise: 24 nV/√Hz
- EMI hardened
- High ESD tolerance: 4 kV HBM
- Extended temperature range: -40 to 125°C
- AEC-Q100 qualified

APPLICATIONS

- Automotive, industrial, power supplies

MiniSO8

SO8

TSB621/2/4: 1.7 MHz rail-to-rail output with wide supply voltage range

The **TSB62 series** of operational amplifiers features an extended operating supply voltage range and rail-to-rail output. It also offers an excellent speed/power consumption ratio and comes in industrial and automotive grade qualification, which makes the TSB62 series an excellent choice for harsh environments with limited power and unstable supply conditions. A variety of different sized packages allows the right package to choose, even for applications where board space is limited.

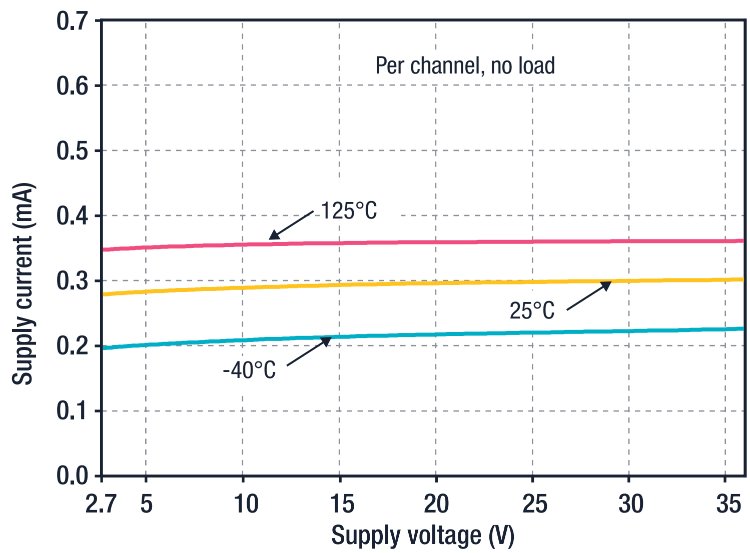
FEATURES

- Low offset voltage: 1 mV max. @ 25°C
- Low current consumption: 375 µA max. / operator @ 36 V
- Wide supply voltage: 2.7 to 36 V
- Gain bandwidth product: 1.7 MHz
- Unity gain stable
- Rail-to-rail output
- Input common mode voltage includes ground
- High ESD tolerance: 4 kV HBM
- EMI hardened
- Extended temperature range: -40 to 125°C
- AEC Q100 automotive qualification

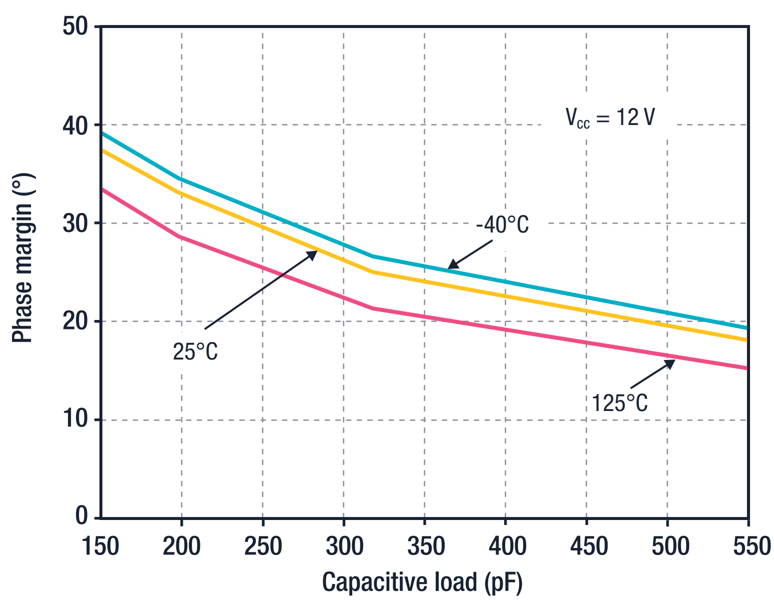
APPLICATIONS

- Solar inverters
- Power supplies
- Active filtering
- Low-side current sensing

Supply current vs. supply voltage



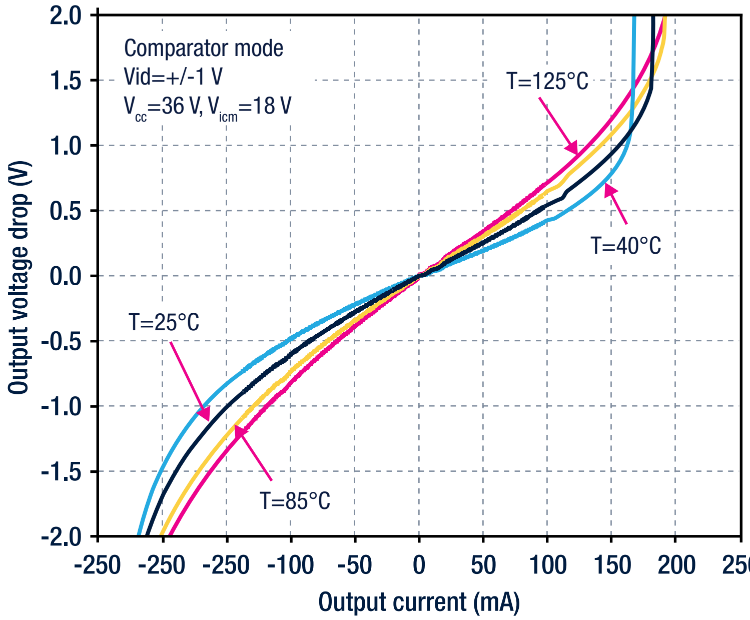
Phase margin vs. capacitive load



TSB582: high output current, rail-to-rail, dual channel with thermal shutdown and output current limiter

The **TSB582** is a high performance dual operational amplifier featuring high supply voltages and high output current capability while being protected through internal current limiting and thermal shutdown. Enhanced ESD and RF immunity facilitate use in harsh automotive environments. Two high output current amplifiers of the TSB582 allow for driving loads directly in bridge tied mode or, connected in parallel, make it possible to double the output sink/source current. Additionally, the TSB582 is available in the two space-saving packages SO8 with exposed pad and DFN8 with wettable flanks. Where both are qualified for automotive applications over a temperature range of -40 to +125°C.

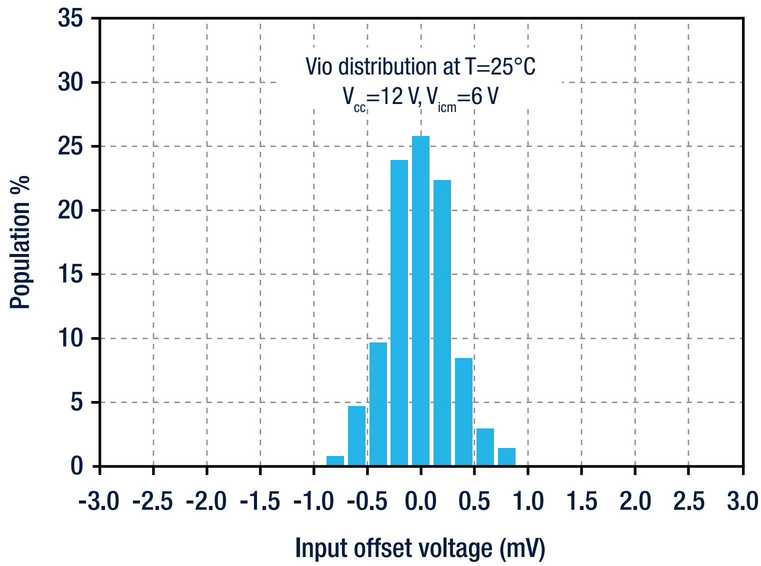
Output current vs. output voltage and temperature



FEATURES

- Wide supply voltage 4 to 36 V
- High output current 2 x 200 mA
- Gain bandwidth product: 3.1 MHz
- Rail-to-rail output, low rail input
- Internal thermal shutdown and output current limiter
- High tolerance to ESD: 4 kV HBM
- Enhanced RF noise immunity
- Extended temperature range: -40 to 125°C

Input offset distribution



Part number	Max. V_{CC} (V)	Min. V_{CC} (V)	Typ. GBP (MHz)	Max. V_{io} @25°C (µV)	Typ. I_{CC} per channel (µA)	Typ. I_{OUT} (mA)	Rail-to-rail In	Rail-to-rail Out	Single	Dual	Quad	Automotive grade
TSB182	36	4	3	20	670	27	No	Yes		•		✓
TSB711/2/1A/2A	36	2.7	6	6	1800	50	Yes	Yes	•	•		✓
TSB571/2	36	4	2.5	1500	380	60	Yes	Yes	•	•		✓
TSB582	36	4	3.1	2400	2500	200	No	Yes		•		✓
TSB611/2	36	2.7	0.56	1600	103	60	No	Yes	•	•		✓
TSB621/2/4	36	2.7	1.7	1600	310	45	No	Yes	•	•	•	✓
TSB511/2/4	36	2.7	6	1500	1800	50	Yes	Yes	•	•	•	✓
TSB7191/2/1A/2A	36	2.7	22	300	1800	50	Yes	Yes	•	•		✓
L2720W	28	4	1.2	10000	10	1000	No	Yes		•		
TSX631/2/4/1A/2A/4A	16	3.3	0.2	700	45	90	Yes	Yes	•	•	•	✓
TSX921	16	4	10	4000	2800	62	Yes	Yes	•			✓
TSX9291	16	4	16	4000	2800	62	Yes	Yes	•			✓
TSX561/2/4/1A/2A/4A	16	3	3	600	250	90	Yes	Yes	•	•	•	✓

RAIL-TO-RAIL, HIGH BANDWIDTH AMPLIFIERS

TSV791/TSV792/TSV794: high bandwidth (50 MHz), rail-to-rail 5 V, low offset (200 µV)

The **TSV791**, **TSV792**, and **TSV794** are unity-gain-stable amplifiers with a bandwidth of 50 MHz. They are single-, dual-, and quad-channel amplifiers, respectively. These amplifiers have a rail-to-rail input stage and a slew rate of 30 V/µs, making them ideal for low-side current measurement. The TSV79 family provides excellent accuracy with a maximum input voltage of 200 µV, allowing for accurate amplification of small amplitude input signals. These amplifiers can operate from a single supply ranging from 2.2 to 5.5 V and can typically handle an output capacitor of up to 1 nF. They are fully specified on a load of 22 pF, easily making them suitable for use as an input buffer for A/D converters.

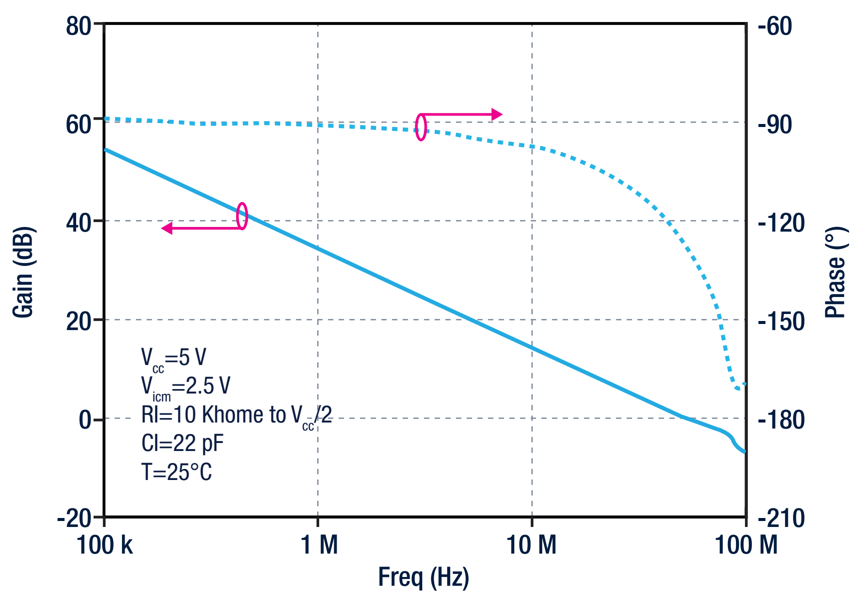
FEATURES

- Gain bandwidth product 50 MHz, unity gain stable
- Slew rate 30 V/µs
- Low input offset voltage 50 µV typ., 200 µV max.
- Low input bias current: 2 pA typ.
- Low input voltage noise density 6.5 nV/√Hz @ 10 kHz
- Wide supply voltage range: 2.2 to 5.5 V
- Rail-to-rail input and output
- Extended temperature range: - 40 to +125°C
- Automotive grade version available

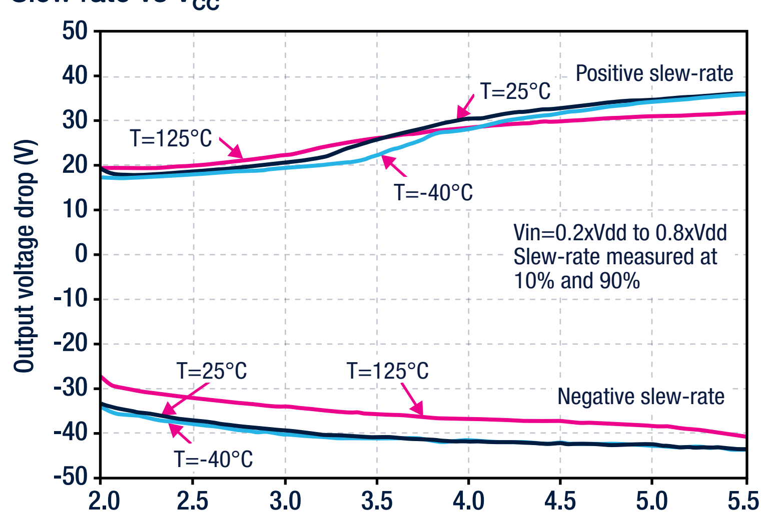
APPLICATIONS

- High bandwidth low-side and high-side current sensing
- Photodiode transimpedance amplification
- A/D converters input buffers
- Power management in solar-powered systems
- Power management in automotive applications

Open loop Bode diagram at V_{CC}=5 V



Slew rate vs V_{CC}



Part number	Typ. GBP (MHz)	Typ. SR (V/µs)	Typ. I_{CC} per channel (µA)	Min. V_{CC} (V)	Max. V_{CC} (V)	Max. V_{IO} @ 25°C (µV)	Typ. 1 kHz noise (nV/√Hz)	Typ. I_{OUT} (mA)	Rail-to-rail		Single	Dual	Quad	Automotive grade
									In	Out				
Fast and high slew rate (GBP ≥ 3 MHz)														
TSZ181/182	3	4.7	800	2.2	5.5	25	37	25	Yes	Yes	•	•		✓
TS512/4	3	1.5	500	6	30	2500	8	23	No	No		•	•	✓
TS951/952/954	3	1	900	2.7	12	6000	25	22	Yes	Yes	•	•	•	✓
TS952/4	3	1	900	2.7	12	6000	25	22	Yes	Yes		•	•	✓
TS9511	3	1	950	2.7	12	800	25	20	Yes	Ye	•			✓
TS921/2	4	1.3	1000	2.7	12	3000	9	80	Yes	Yes	•	•		
TS9222/4	4	1.3	900	2.7	12	500	9	80	Yes	Yes		•	•	✓
LMV820/3	5.5	1.9	300	2.5	5.5	3500	16	56	No	Yes	•	•		
LMV820A/3A	5.5	1.9	300	2.5	5.5	800	16	56	No	Yes	•	•		
LMV821/2/4	5.5	1.9	300	2.5	5.5	3500	16	56	No	Yes	•	•	•	✓
LMV821A/2A/4A	5.5	1.9	300	2.5	5.5	800	16	56	No	Yes	•	•	•	✓
TSB711/TSB712	6	3	1800	2.7	36	800	12	50	Yes	Yes	•	•		✓
TSB711A/TSB712A	6	3	1800	2.7	36	300	12	50	Yes	Yes	•	•		✓
TSV911A/2A/4A	8	4.5	780	2.5	5.5	1500	27	35	Yes	Yes	•	•	•	✓
TSV912H	8	4.5	780	2.5	5.5	4500	27	35	Yes	Yes		•		✓
TSV911/2/4	8	4.5	780	2.5	5.5	4500	27	35	Yes	Yes	•	•	•	✓
TSX7191/2	9	2.3	660	2.7	16	200	22	50	Yes	Yes	•	•		✓
TSX7191A	9	2.3	660	2.7	16	100	22	50	Yes	Yes	•			✓
TSX920/923	10	17.2	2800	4	16	4000	16.5	62	Yes	Yes	•	•		
TSX921/922	10	17.2	2800	4	16	4000	16.5	62	Yes	Yes	•	•		✓
TS971/2/4	12	4	2000	2.7	10	5000	4	100	No	Yes	•	•	•	✓
TSX9291/TSX9292	16	26	2800	4	16	4000	16.5	62	Yes	Yes	•	•		✓
TSV771/2/4	20	13	1900	2	5.5	200	13	65	Yes	Yes	•	•	•	✓
TSV7721/2/3	20	11	1700	1.8	5.5	200	13	65	No	Yes	•	•		✓
TSV991/2/4	20	10	820	2.5	5.5	4500	27	35	Yes	Yes	•	•	•	✓
TSV991A/2A/4A	20	10	820	2.5	5.5	1500	27	35	Yes	Yes	•	•	•	✓
TSB7191/TSB7192	22	12	1800	2.7	36	800	12	50	Yes	Yes	•	•		✓
TSB7191A/TSB7192A	22	12	1800	2.7	36	300	12	50	Yes	Yes	•	•		✓
TSV781/2	30	19	3300	2	5.5	200	14	65	Yes	Yes		•		✓
TSV791/2/4	50	30	5000	2.2	5.5	200	6.5	65	Yes	Yes	•	•	•	✓

Any non-automotive product may be eligible for AEC-Q100 qualification. Contact ST Sales representative for additional information.

SMALL PACKAGES

TSV772IQ2T: high bandwidth (20 MHz), rail-to-rail 5 V, 200 µV accuracy

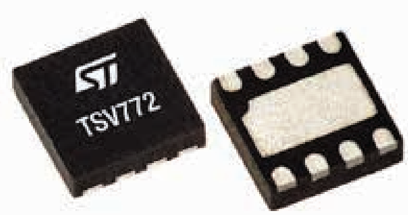
The **TSV772IQ2T** is a unity-gain-stable amplifier with a bandwidth of 20 MHz. It is a dual amplifier with a rail-to-rail input stage and a slew rate of 10.5 V/µs, making it ideal for low-side current measurement. This device provides excellent accuracy with a maximum input voltage of 200 µV, allowing for accurate amplification of small amplitude input signals. This amplifier can operate from a single supply ranging from 2.0 to 5.5 V and is fully characterized for an output capacitor of 47 pF, making it suitable for use as an A/D converters input buffer with easy usage.

FEATURES

- Low input offset voltage: 50 µV typ., 200 µV max.
- Wide supply voltage range: 2.0 to 5.5 V
- Gain bandwidth product: 20 MHz, unity gain stable
- Low input bias current: 2 pA typ.
- Low noise: 7 nV/√Hz
- Low input bias current: 2 pA (typ.)
- Rail-to-rail input and output
- Extended temperature range: -40 to +125°C

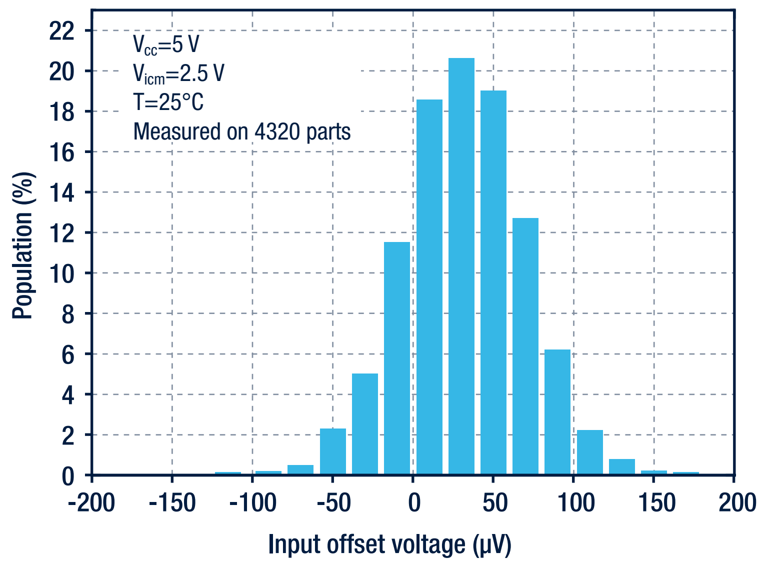
APPLICATIONS

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

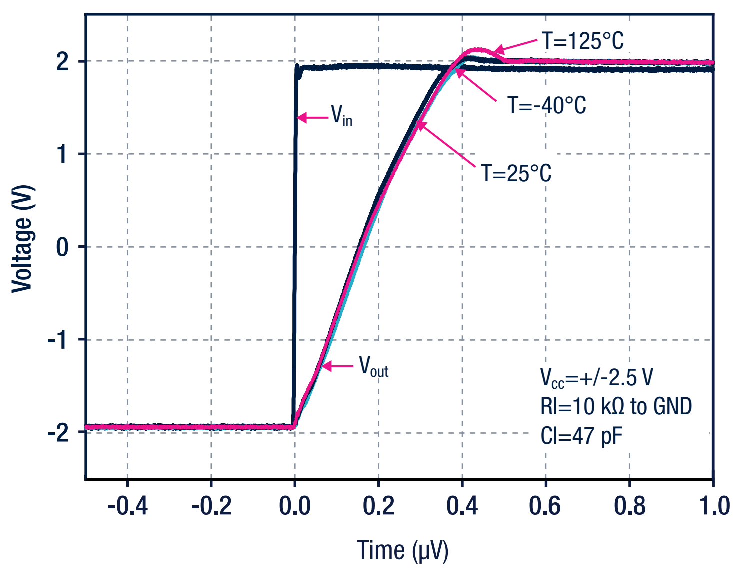


DFN8

Input offset voltage distribution at V_{CC} = 5 V



Positive slew rate at V_{CC} = 5 V



Part number	Single	Dual	Quad	Min. V_{CC} (V)	Max V_{CC} (V)	Typ. GBP (MHz)	Typ. I_{CC} per channel (µA)	Max. V_{IO} @ 25°C (µV)	Rail-to-rail		Automotive grade
									In	Out	
Small packages											
LMV321L/358L/324L	SC70-5	*	*	2.7	5.5	1.3	130	7000	No	Yes	
LMV821/2/4	SC70-5	DFN8	*	2.5	5.5	5.5	300	3500	No	Yes	✓
LMV821A/2A/4A	SC70-5	*	*	2.5	5.5	5.5	300	800	No	Yes	✓
LMX321/358/324	SC70-5	DFN8	*	2.5	5.5	1.3	180	4000	No	Yes	
LM2902/2B/4/4B/4AH		DFN8	QFN16	3	36	1.3	350	4000	No	No	✓
TS921/2/4	*	CSP	*	2.7	12	4	1000	3000	Yes	Yes	✓
TS971/2/4	*	DFN8	*	2.7	10	12	2000	5000	No	Yes	✓
TSB572		DFN8		4	36	2.5	380	1500	Yes	Yes	✓
TSB582		DFN8		4	36	3.1	2500	2400	No	Yes	✓
TSB621/2/4	*	DFN8	*	2.7	36	1.7	310	1000	No	Yes	✓
TSU101/2/4	SC70-5	DFN8	QFN16	1.5	5.5	0.008	0.58	3000	Yes	Yes	
TSU111/2/4	SC70-5	DFN8	QFN16	1.5	5.5	0.0115	0.9	150	Yes	Yes	
TSU111IY/12IY	SC70-5	DFN8		1.5	5.5	0.009	0.92	150	Yes	Yes	✓
TSV521/2/4	SC70-5	DFN8	QFN16	2.7	5.5	1.15	45	1000	Yes	Yes	✓
TSV521A/2A/4A	SC70-5	DFN8	QFN16	2.7	5.5	1.15	45	600	Yes	Yes	✓
TSV611/2	SC70-5	*		1.5	5.5	0.12	10	4500	Yes	Yes	
TSV611A/2A	SC70-5	*		1.5	5.5	0.12	10	800	Yes	Yes	
TSV6191/2	SC70-5	*		1.5	5.5	0.45	10	4500	Yes	Yes	
TSV6191A/2A	SC70-5	*		1.5	5.5	0.45	10	800	Yes	Yes	
TSV620/3/5	SC70-6	*	*	1.5	5.5	0.42	29	4000	Yes	Yes	
TSV620A/3A	SC70-6	*		1.5	5.5	0.42	29	800	Yes	Yes	
TSV621/2/4	SC70-5	*	*	1.5	5.5	0.42	29	4000	Yes	Yes	
TSV621A/2A/4A	SC70-5	*	*	1.5	5.5	0.42	29	800	Yes	Yes	
TSV6290/3	SC70-6	*		1.5	5.5	1.3	29	4000	Yes	Yes	
TSV6290A/3A	SC70-6	*		1.5	5.5	1.3	29	800	Yes	Yes	
TSV6291/2/4	SC70-5	*	*	1.5	5.5	1.3	29	4000	Yes	Yes	
TSV6291A/2A/4A	SC70-5	*	*	1.5	5.5	1.3	29	800	Yes	Yes	
TSV630/3/5	SC70-6	*	*	1.5	5.5	0.88	60	3000	Yes	Yes	
TSV630A/3A/5A	SC70-6	*	*	1.5	5.5	0.88	60	500	Yes	Yes	
TSV631/2/4	SC70-5	DFN8	QFN16	1.5	5.5	0.88	60	3000	Yes	Yes	✓
TSV631A/2A/4A	SC70-5	DFN8	*	1.5	5.5	0.88	60	500	Yes	Yes	
TSV6390/3/5	SC70-6	*	*	1.5	5.5	2.4	60	3000	Yes	Yes	
TSV6390A/3A	SC70-6	*		1.5	5.5	2.4	60	500	Yes	Yes	
TSV6391/2/4	SC70-5	*	*	1.5	5.5	2.4	60	3000	Yes	Yes	
TSV6391A/2A/4A	SC70-5	*	*	1.5	5.5	2.4	60	500	Yes	Yes	
TSV711/2/4	SC70-5	DFN8	QFN16	1.5	5.5	0.12	10	200	Yes	Yes	
TSV731/2/4	SC70-5	DFN8	QFN16	1.5	5.5	0.9	60	200	Yes	Yes	
TSV851/2/4	SC70-5	DFN8	QFN16	2.3	5.5	1.3	180	4000	No	Yes	✓
TSV851A/2A/4A	SC70-5	*	*	2.3	5.5	1.3	180	800	No	Yes	✓
TSV991/2/4	*	DFN8	*	2.5	5.5	20	820	4500	Yes	Yes	✓
TSV991A/2A/4A	*	*	*	2.5	5.5	20	820	1500	Yes	Yes	✓
TSV771/2/4	*	DFN8	*	2	5.5	20	1900	200	Yes	Yes	✓
TSV7721/2	*	DFN8		1.8	5.5	22	1700	200	No	Yes	✓
TSV781/2	*	DFN8		2	5.5	30	3300	200	Yes	Yes	✓
TSV791/2/4	*	DFN8	*	2.2	5.5	50	5300	200	Yes	Yes	✓
TSV911/2/4	*	DFN8	*	2.5	5.5	8	780	4500	Yes	Yes	✓
TSX561/2/4	*	DFN8	QFN16	3	16	0.9	250	1000	Yes	Yes	✓
TSX631/2/4	*	DFN8	QFN16	3.3	16	0.2	45	1000	Yes	Yes	✓
TSX921/2	*	DFN8		4	16	10	2800	4000	Yes	Yes	✓
TSX9291/2	*	DFN8		4	16	16	2800	4000	Yes	Yes	✓
TSZ121/2/4	SC70-5	DFN8	QFN16	1.8	5.5	0.4	31	5	Yes	Yes	✓
TSZ151	SC70-5			1.8	5.5	1.3	300	7	Yes	Yes	✓
TSZ181/182	*	DFN8		2.2	5.5	3	800	25	Yes	Yes	✓

* Other packages are available.

EMI HARDENED

TSB572: low-power, 2.5 MHz, rail-to-rail input and output, 36 V

The **TSB572** is a dual-channel operational amplifier that provides an extended voltage operating range from 4 to 36 V and rail-to-rail input/output. This amplifier offers a very good speed/current consumption ratio with a gain bandwidth product of 2.5 MHz while consuming only 380 µA typically with a 36 V supply. The TSB572 is stable and robust, making it an ideal solution for a wide range of applications requiring an extended operating voltage.

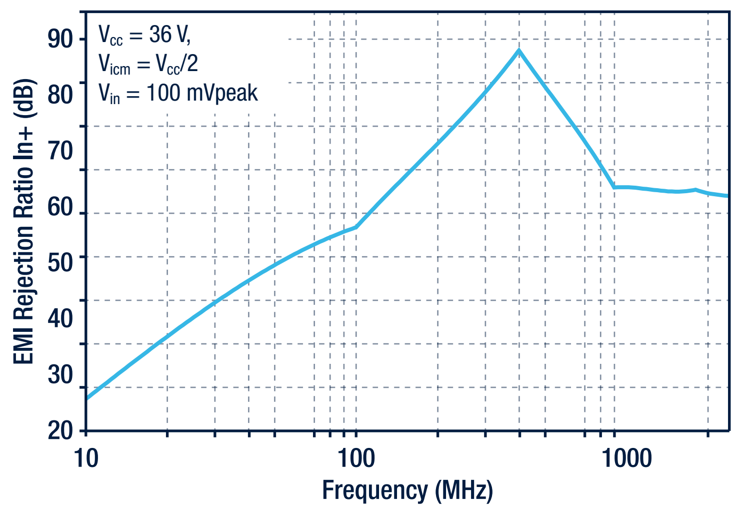
FEATURES

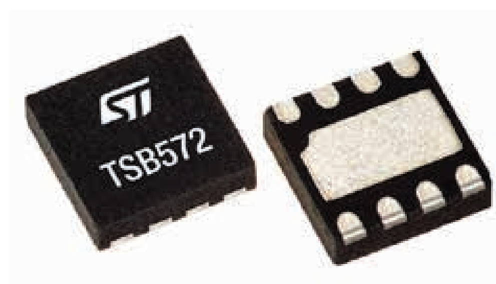
- Low-power consumption: 380 µA (typ.)
- Wide supply voltage: 4 to 36 V
- Rail-to-rail input and output
- Gain bandwidth product: 2.5 MHz
- Low input bias current: 30 nA (max.)
- High tolerance to ESD: 4 kV HBM
- Extended temperature range: -40 to +125°C
- Automotive grade

APPLICATIONS

- Active filtering
- Audio systems
- Automotive
- Power supplies
- Industrial
- Low high-side current sensing

EMI rejection ratio V_{CC} = 36 V





DFN8

Part number	Min. V_{CC} (V)	Max. V_{CC} (V)	Typ. GBP (MHz)	Typ. SR (V/µs)	Typ. I_{CC} per channel (µA)	Max. V_{IO} @ 25°C (µV)	Typ. I_{OUT} (mA)	Rail-to-rail In	Rail-to-rail Out	Single	Dual	Quad	Automotive grade
EMI hardened													
TSV711/2/4	1.5	5.5	0.12	0.06	10	200	45	Yes	Yes	•	•	•	
TSV731/2/4	1.5	5.5	0.90	0.35	60	200	52	Yes	Yes	•	•	•	
TSV632A/4A	1.5	5.5	0.88	0.34	60	500	69	Yes	Yes		•	•	✓
TSZ121/2/4	1.8	5.5	0.40	0.19	31	5	17	Yes	Yes	•	•	•	✓
TSZ181/182	2.2	5.5	3.00	4.70	800	25	25	Yes	Yes	•	•		✓
TSX711A/2	2.7	16.0	2.70	1.20	660	100	54	Yes	Yes	•	•		✓
TSX561A/2A/4A	3.0	16.0	0.90	1.10	250	600	90	Yes	Yes	•	•	•	✓
TSX631A/2A/4A	3.3	16.0	0.20	0.12	45	500	90	Yes	Yes	•	•	•	✓
TSB571/2	4.0	36.0	2.50	1.00	380	1500	60	Yes	Yes	•	•		✓

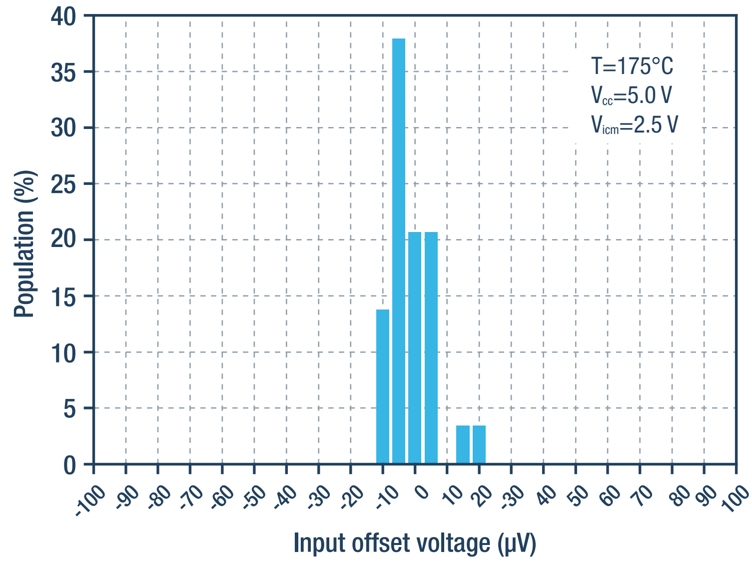
Any non-automotive product may be eligible for AEC-Q100 qualification. Contact ST Sales representative for additional information.

HIGH OPERATING TEMPERATURE

TSZ181H/H1, TSZ182H/H1: very high accuracy (70 µV), zero-drift, high bandwidth (3 MHz), high temperature

The **TSZ181H/H1** and the **TSZ182H/H1** are composed of single- and dual-channel operational amplifiers that have an extremely low offset voltage with minimized drift versus temperature changes. The TSZ181H/H1 and the TSZ182H/H1 have rail-to-rail input and output, an excellent speed/current consumption ratio, and a gain bandwidth product of 3 MHz, while only using 1 mA at 5 V. These devices work in a wide range of temperatures, from -40 to +175°C, and have an incredibly low input bias current. These characteristics make them perfect for high-precision, high-bandwidth sensor interfaces in the automotive environment.

Input offset voltage distribution at V_{CC} =5 V, T=175°C



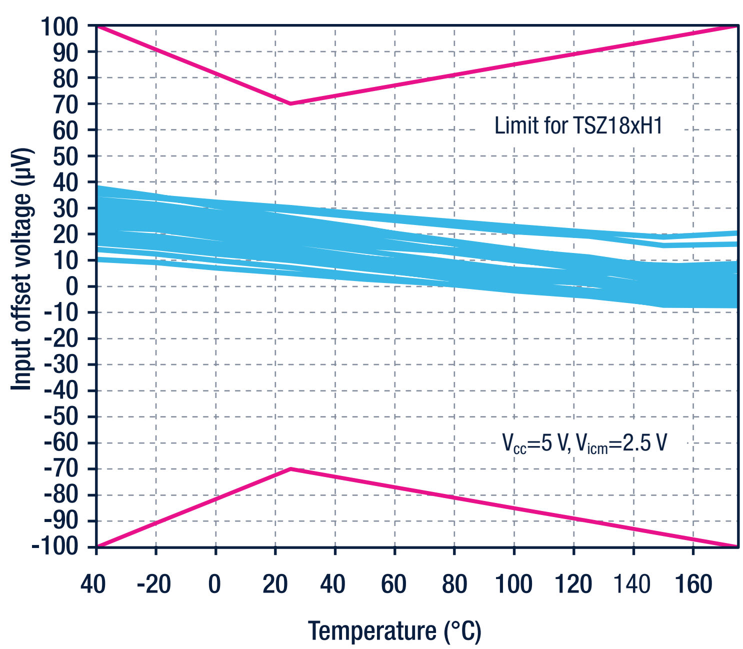
FEATURES

- AEC-Q100 qualified
- Very high accuracy and stability:
  - -70 µV max. offset voltage at 25°C (TSZ181H1, TSZ182H1)
  - -100 µV offset voltage over full temperature range (TSZ181H1, TSZ182H1)
  - -25 µV max. offset voltage at 25°C (TSZ181H, TSZ182H)
  - -440 µV offset voltage over full temperature range (TSZ181H, TSZ182H)
- Rail-to-rail input and output
- Low supply voltage: 2.2 to 5.5 V
- Low power consumption: 1 mA max. at 5 V
- Gain bandwidth product: 3 MHz
- Extended temperature range: -40 to 150 (H) 175°C (H1)
- Micropackages: SOT23-5, SO8

APPLICATIONS

- High accuracy signal conditioning
- Current measurement
- Sensor signal conditioning
- Automotive

Input offset voltage vs. temperature



Part number	Typ. GBP (MHz)	Typ. SR (V/µs)	Min. V_{cc} (V)	Max. V_{cc} (V)	Typ. I_{cc} per channel (µA)	Rail-to-rail		Operating temperature range	Package	Single	Dual	Automotive grade
						In	Out					
High temperature range amplifiers												
TSU111H	0.023	5.5	1.5	5.5	1.7	Yes	Yes	-40 to +150°C	SOT23-5	•		✓
LM2904AH/WH	1.1	0.6	3	30	350	GND	No	-40 to +150°C	TSSOP8, DFN8, SO8, MiniSO8		•	✓
TSZ181H1/182H1	3	4.7	2.2	5.5	800	Yes	Yes	-40 to 175°C	SOT23-5, SO8	•	•	✓
TSZ181H/182H	3	4.7	2.2	5.5	800	Yes	Yes	-40 to 150°C	SOT23-5, SO8	•	•	✓
TSV912H	8	4.5	2.5	5.5	820	Yes	Yes	-40 to +150°C	SO8		•	✓

Any non-automotive product may be eligible for AEC-Q100 qualification. Contact ST Sales representative for additional information.

AUDIO AMPLIFIERS

TS971/2/4: output rail-to-rail very low noise

The **TS971**, **TS972**, and **TS974** operational amplifiers can operate at voltages as low as ±1.35 V and feature an output signal swing that reaches both the positive and negative voltage rails. These devices are well-suited for use in portable and battery-powered equipment due to their low noise and distortion characteristics, which make them ideal for audio pre-amplification. The TS97 series is available in various package options to accommodate a wide range of applications. For space-constrained applications, the SOT23-5 package (2.8 x 2.9 mm) or the DFN8 package (3 x 3 mm) can be placed anywhere on the board, simplifying the design process.

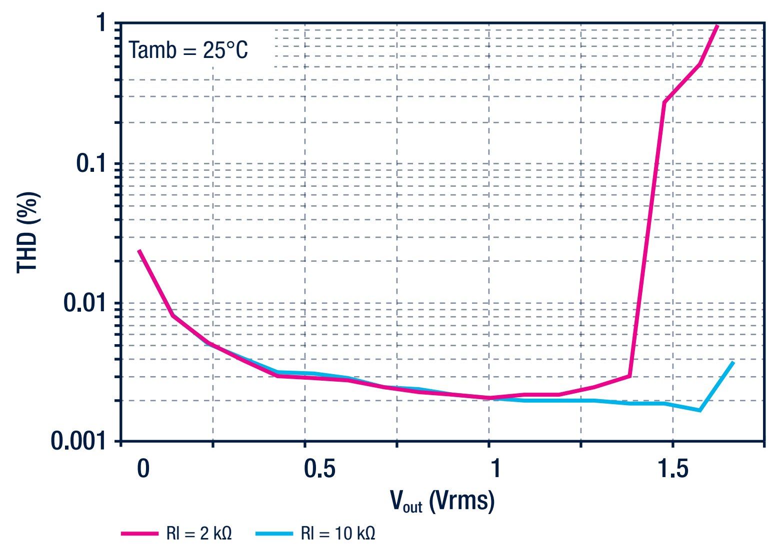
FEATURES

- Rail-to-rail output voltage swing ±2.4 V at V_{CC} = ±2.5 V
- Very low noise level: 4 nV/√Hz
- Ultra-low distortion: 0.003%
- High dynamic features: 12 MHz, 4 V/µs
- Supply voltage: 2.7 to 10 V, ±1.35 to 5 V
- ESD protection: 2 kV HBM
- Latch-up immunity (Class A)

APPLICATIONS

- Portable and handheld devices
- Professional audio circuits
- Industrial
- Low/high-side current sensing

THD vs V_{OUT}, V_{CC} = 5 V



Part number	Typ. GBP (MHz)	Typ. SR (V/µs)	Typ. THD @ 1 kHz (%)	Min. V_{CC} (V)	Max. V_{CC} (V)	Typ. I_{CC} per channel (µA)	Typ. A_{VD} (dB)	Typ. 1 kHz noise (nV/√Hz)	Rail-to-rail out	Operating temp.range (°C)	Package	Single	Dual	Quad
Audio amplifiers														
TS921/2A/4A	4	1.3	0.005	2.7	12	1000	91	9	Yes	-40 to +125	Flip-chip, SO8, TSSOP8, SO14, TSSOP14, SOT23-5	•	•	•
TS461/2/4	12	4	0.003	2.7	10	2000	80	4	Yes	-20 to 70	SOT23-5, SO8, MiniSO8, TSSOP8, SO14, TSSOP14	•	•	•
TS971/2/4	12	4	0.003	2.7	10	2000	80	4	Yes	-40 to +125	SOT23-5, SO8, DFN8, TSSOP8, SO14, TSSOP14	•	•	•
MC33078/9	15	7	0.002	5	30	2000	100	4.5	No	-40 to +125	SO8, SO14		•	•

CLASS AB, CLASS D AND HEADPHONE AMPLIFIERS

TS488: pop-free 120 mW stereo headphone amplifier

The **TS488** eliminates pop and click noise and reduces the number of external passive components. The TS488 is a dual audio power amplifier capable of driving, in single-ended mode, either a 16 Ω or a 32 Ω stereo headset. Capable of descending to low voltages, it delivers up to 31 mW per channel (into 16 Ω loads) of continuous average power with 0.1% THD+N in the audio bandwidth from a 2.5 V power supply. An externally-controlled standby mode reduces the supply current to 10 nA (typ.).
The unity gain stable TS488 is configured by external gain-setting resistors.

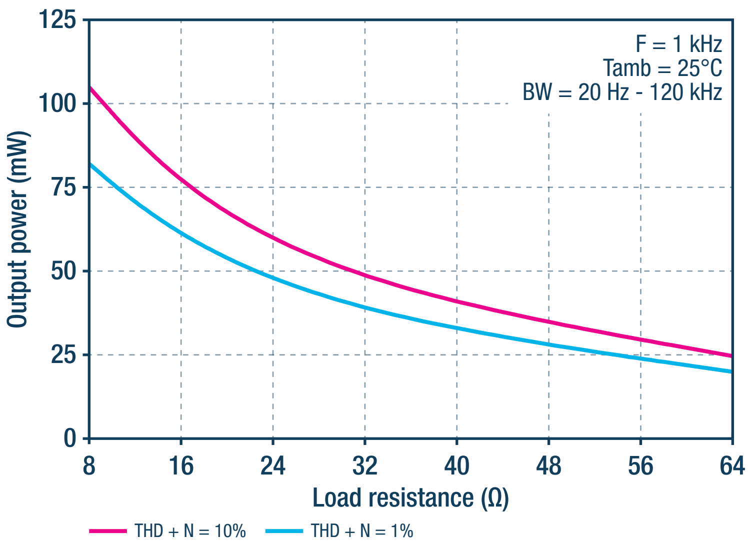
FEATURES

- Pop and click noise protection circuitry
- Operating range from V_{CC} = 2.2 to 5.5 V
- Output power:
  - 120 mW at 5 V, into 16 Ω with 0.1% THD+N (max.) (1 kHz)
  - 55 mW at 3.3 V, into 16 Ω with 0.1% THD+N (max.) (1 kHz)
- Low current consumption: 2.7 mA (max.) at 5 V
- Ultra-low standby current consumption: 10 nA (typ.)
- High crosstalk immunity: 102 dB (1 kHz)
- Short-circuit protection circuitry
- DFN8 package

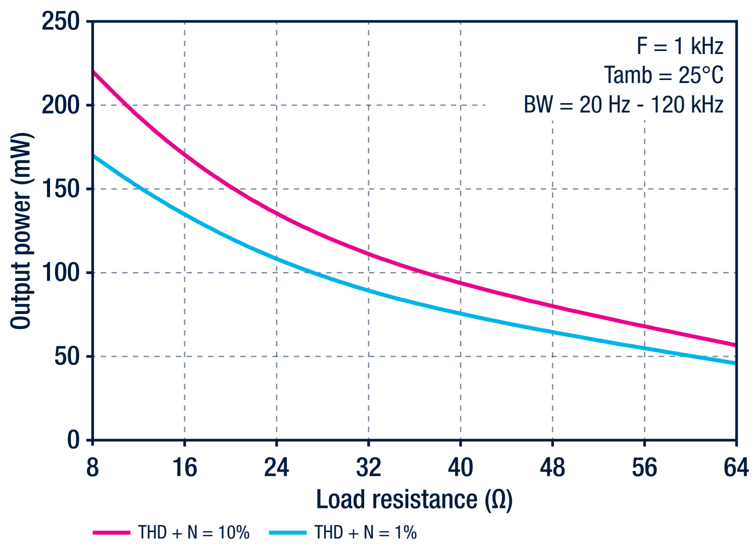
APPLICATIONS

- Headphone amplifiers
- Mobile phones, handheld devices, and computer motherboards
- High-end TVs and portable audio players

Output power vs. load resistance V_{CC} = 3.3 V



Output power vs. load resistance V_{CC} = 5 V



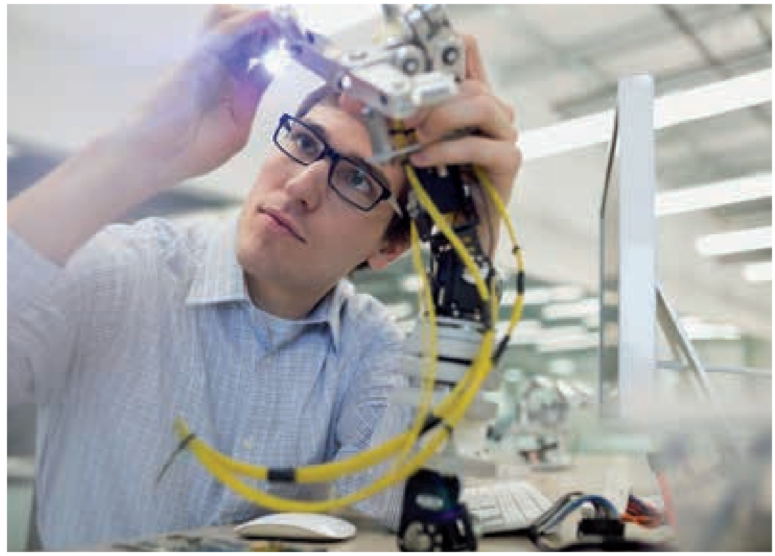
<table>
<tr><th rowspan="2">Part number</th><th colspan="2">Output power per channel</th><th rowspan="2">Min. V_{cc} (V)</th><th rowspan="2">Max. V_{cc} (V)</th><th rowspan="2">Input</th><th rowspan="2">Mono/ Stereo</th><th rowspan="2">Typ. I_{cc} no load (mA)</th><th rowspan="2">Typ. SNR (dB)</th><th rowspan="2">Gain control</th><th rowspan="2">Pop and noise cancellation</th><th rowspan="2">Max. Stdby I_{cc} (µA)</th><th rowspan="2">Package</th></tr>
<tr><th>@ 1% THD V_{cc} max. (W)</th><th>@ 10% THD V_{cc} max. (W)</th></tr>
<tr><th colspan="13">Class AB audio low power amplifiers</th></tr>
<tr><td>TS4871/ TS4890</td><td>1.28 W into 4 Ω
1 W into 8 Ω</td><td>2.08 W into 4 Ω
1.45 W into 8 Ω</td><td>2.5</td><td>5.5</td><td rowspan="2">Single-ended</td><td rowspan="4">Mono</td><td>6</td><td>97</td><td>External res</td><td rowspan="5">Yes</td><td>1</td><td>SO8, MiniSO8</td></tr>
<tr><td>TS4990</td><td>1.2 W into 8 Ω
0.7 W into 16 Ω</td><td>1.5 W into 8 Ω
0.88 W into 16 Ω</td><td>2.2</td><td>5.5</td><td>3.7</td><td>103</td><td>External res</td><td>1</td><td>SO8, MiniSO8, DFN8 3x3, Flip-chip9</td></tr>
<tr><td>TS4994</td><td>1 W into 8 Ω
0.6 W into 16 Ω</td><td>1.48 W into 8 Ω
0.9 W into 16 Ω</td><td>2.5</td><td>5.5</td><td rowspan="2">Differential</td><td>4</td><td>100</td><td>External res</td><td>1</td><td>DFN10 3x3, MiniSO8</td></tr>
<tr><td>TS4995</td><td>1.2 W into 8 Ω
0.7 W into 16 Ω</td><td>1.5 W into 8 Ω
0.88 W into 16 Ω</td><td>2.5</td><td>5.5</td><td>4</td><td>100</td><td>External res/ 6 dB</td><td>1</td><td>Flip-chip9</td></tr>
<tr><td>TS4984</td><td>1 W into 8 Ω
0.65 W into 16 Ω</td><td>1.25 W into 8 Ω
0.8 W into 16 Ω</td><td>2.2</td><td>5.5</td><td>Single-ended</td><td>Stereo</td><td>7.4</td><td>100</td><td>External res</td><td>1</td><td>QFN16 4x4</td></tr>
<tr><th colspan="13">Headphone amplifiers</th></tr>
<tr><td>TS419/21</td><td>295 mW into 16 Ω
207 mW into 32 Ω</td><td>367 mW into 16 Ω
258 mW into 32 Ω</td><td>2</td><td>5.5</td><td rowspan="4">Single-ended</td><td>Mono</td><td>6.0</td><td>98</td><td>External res</td><td rowspan="5">Yes</td><td>1</td><td>MiniSO8, DFN8 3x3</td></tr>
<tr><td>TS482</td><td>107 mW into 16 Ω
67.5 mW into 32 Ω</td><td>131 mW into 16 Ω
82 mW into 32 Ω</td><td>2</td><td>5.5</td><td rowspan="4">Stereo</td><td>5.5</td><td>110</td><td>External res</td><td>N/A</td><td>SO8, MiniSO8</td></tr>
<tr><td>TS488</td><td>120 mW into 16 Ω
80 mW into 32 Ω</td><td>160 mW into 16 Ω
100 mW into 32 Ω</td><td>2.2</td><td>5.5</td><td>2</td><td>105</td><td>External res</td><td>1</td><td>DFN8 2x2</td></tr>
<tr><td>TS4909</td><td>158 mW into 16 Ω
88 mW into 32 Ω</td><td>190 mW into 16 Ω
105 mW into 32 Ω</td><td>2.2</td><td>5.5</td><td>2.1</td><td>105</td><td>External res</td><td>1</td><td>DFN10 3x3</td></tr>
<tr><td>TS4621E/ TS4621ML</td><td>65 mW into 16 Ω
43 mW into 32 Ω</td><td>92 mW into 16 Ω
58 mW into 32 Ω</td><td>2.3</td><td>4.8</td><td>Differential</td><td>1.2</td><td>100</td><td>I^2C/ Dedicated pin</td><td>5</td><td>Flip-chip16</td></tr>
<tr><th colspan="13">Microphone preamplifiers</th></tr>
<tr><td>TS472</td><td>N/A</td><td>N/A</td><td>2.2</td><td>5.5</td><td>Differential</td><td>Differential</td><td>1.8</td><td>90</td><td>External res</td><td>N/A</td><td>1</td><td>QFN24 4x4, Flip-chip12</td></tr>
<tr><th colspan="13">Class D audio low power amplifiers</th></tr>
<tr><td>TS2007FC</td><td>2.3 W into 4 Ω
1.4 W into 8 Ω</td><td>3 W into 4 Ω
1.75 W into 8 Ω</td><td>2.4</td><td>5.5</td><td rowspan="3">Differential</td><td>Mono</td><td>2.5</td><td>93</td><td>6 dB, 12 dB</td><td rowspan="3">Yes</td><td>2</td><td>Flip-chip9</td></tr>
<tr><td>TS4962</td><td>2.2 W into 4 Ω
1.4 W into 8 Ω</td><td>2.8 W into 4 Ω
1.7 W into 8 Ω</td><td>2.4</td><td>5.5</td><td>Mono</td><td>2.3</td><td>85</td><td>External res</td><td>1</td><td>DFN8 2x2</td></tr>
<tr><td>TS4962M</td><td>2.3 W into 4 Ω
1.4 W into 8 Ω</td><td>3 W into 4 Ω
1.75 W into 8 Ω</td><td>2.4</td><td>5.5</td><td>Stereo</td><td>2.3</td><td>85</td><td>External res</td><td>2</td><td>Flip-chip9</td></tr>
</table>

CURRENT-SENSE AMPLIFIERS

TSC2020: precision, bidirectional current sense amplifier with a wide set of common mode voltages

The **TSC2020** is a bidirectional current sense amplifier that provides precise measurement of current via a shunt resistor. It can sense current over a wide range of common mode voltages, from -4 to +100 V, regardless of the supply voltage. Moreover, it can sense very low drop voltages, minimizing measurement errors.

The TSC2020 may be used in various applications, including precision current measurement, overcurrent protection, current monitoring, and feedback loops. This device fully operates over the supply voltage range of 2.7 to 5.5 V and over the industrial temperature range of -40 to 125°C.



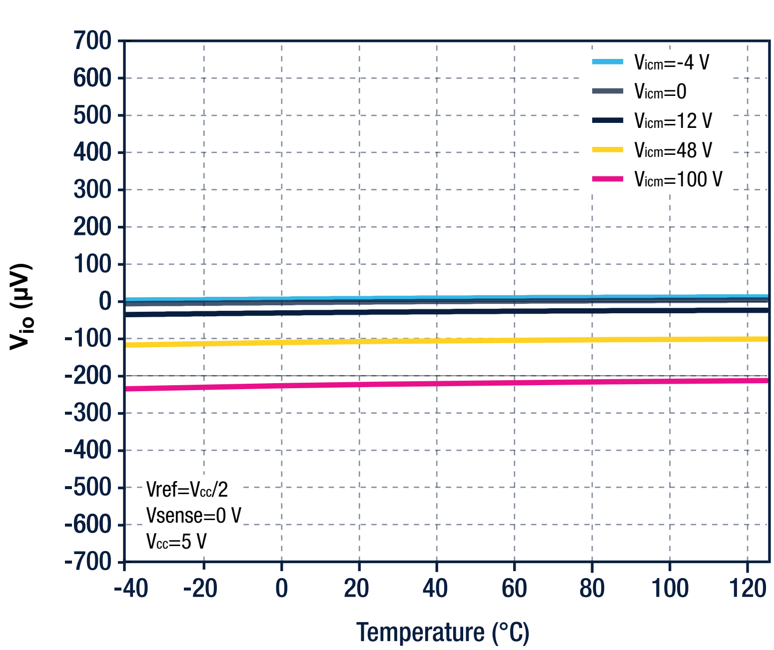
FEATURES

- Wide common mode voltage: -4 to 100 V
- High common mode rejection CMR: 100 dB min.
- Offset voltage: ±150 µV max.
- Offset drift: 0.5 µV/°C max.
- Enhanced PWM rejection
- 2.7 to 5.5 V supply voltage
- Internal fixed gain 20 V/V
- Gain error: 0.3% max.
- Gain drift: 3.5 ppm/°C max.
- SO8 and MiniSO8 packages
- AEC-Q100 qualified

APPLICATIONS

- High-side/low-side current sensing
- Battery management system
- 48 V power distribution
- 48 V power tools
- Motor control
- Automotive

Input offset voltage vs. temperature



SO8 MiniSO8

Current sense amplifiers

Part number	Type	Vio (mV) Max.	Max. I_{cc} (µA)	Common mode operating range (V)		V_{cc} (V)		Voltage gain (V/V)	Operating temperature (°C)		Package	Automotive grade
				Min.	Max.	Min.	Max.		Min.	Max.		
Hide side current sensing												
TSC101	Unidirectional	1.5	300	2.8	30	4	24	20, 50, 100	-40	125	SOT23-5	✓
TSC888	Unidirectional	-	1000	2.8	24	4	24	20, 50, 100	-40	125	SOT23-5	
TSC102	Unidirectional	1.5	420	2.8	30	3.5	5.5	Adjustable	-40	125	TSSOP8, SO8	✓
TSC1021	Unidirectional	1.5	300	2.8	30	3.5	5.5	20, 50	-40	125	TSSOP8	✓
TSC103	Unidirectional	0.5	360	2.9	70	2.7	5.5	20, 25, 50, 100	-40	125	TSSOP8, SO8	✓
TSC1031	Unidirectional	0.5	360	2.9	70	2.7	5.5	50, 100	-40	125	TSSOP8, SO8	✓
TSC200/201/202	Unidirectional	2.5	1800	-16	80	2.7	18	20	-40	125	MiniSO8, SO8	✓
TSC2010/2011/2012	Bidirectional	0.2	2300	-20.0	70	2.7	5.5	20, 60, 100	-40	125	SO8, MiniSO8	✓
TSC210/211/212/213/ 214/215	Bidirectional	0.035	100	-0.3	26	2.7	26	200, 500, 1000, 50, 100, 75	-40	125	QFN10L, SC70-6	✓
TSC2020	Bidirectional	0.15	2300	-4	100	2.7	5.5	20	-40	125	SO8, MiniSO8	✓
TSC2010H/2011H/2012H	Bidirectional	0.2	1500	-20	70	2.7	5.5	20, 60, 100	-40	+150	SO8	✓

Any non-automotive product may be eligible for AEC-Q100 qualification. Contact ST Sales representative for additional information.

Evaluation boards

Order code	Description	Reference
STEVAL-ISQ007V1	High-side current-sense amplifier demonstration board based on TSC101	AN2727
STEVAL-ISQ010V1	High-side current-sense amplifier demonstration board based on TSC102	DB0982
STEVAL-ISQ013V1	Low-side current sensing based on TS507	AN3222
STEVAL-ISQ014V1	Low-side current sensing based on TSZ121	UM1737
STEVAL-AETKT1V2	High voltage bidirectional current sense amplifier based on the TSC2010/11/12	DB4277
STEVAL-AETKT2V1	high precision bidirectional current sense amplifiers based on the TSC2010/13	DB4471

Comparators

LOW POWER

TS880/3: 0.9 V rail-to-rail nanopower comparators

The open-drain series of nanopower comparators includes two options: the single-channel **TS880** and the dual-channel **TS883**. Both comparators offer an ultra-low supply current of just 250 nA per operator, on average, and feature rail-to-rail input capability and open-drain output. These comparators are highly versatile and well-suited for use in a variety of portable applications. In particular, the TS880 and TS883 comparators are designed to minimize battery supply leakage, which can help to extend battery life and reduce the need for frequent battery replacements.

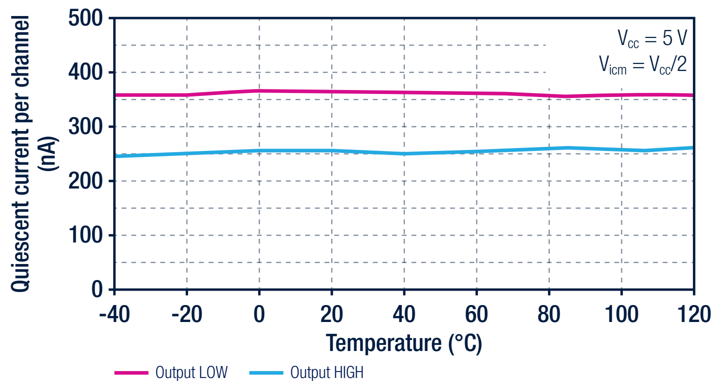
FEATURES

- 900 nA per channel at 25°C
- Ultra-low current consumption: 250 nA typ./op.
- Propagation delay: 2 µs (typ.)
- Rail-to-rail inputs
- Open-drain outputs
- Supply operation from 0.9 to 5.5 V
- Wide temperature range: -40 to +125°C
- ESD tolerance: 8 kV HBM
- Single version available in SC70-5 and SOT23-5 packages
- Dual version available in MiniSO8 and DFN8 2x2 mm packages

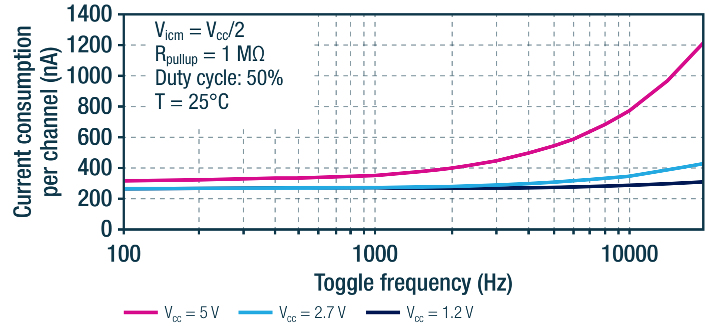
APPLICATIONS

- Portable systems
- Signal conditioning
- Medical

Current consumption vs. temperature



Current consumption vs. toggle frequency



Part number	Typ. I_{cc} per channel (µA)	Min. V_{cc} (V)	Max. V_{cc} (V)	Typ. response time (ns) 100 mV overdrive	Temperature range (°C)	Rail-to-rail in	Output type	Input type	Single	Dual	Quad	Automotive grade
Nanopower												
TS881	0.21	0.85	5.5	2600	-40 to 125	Yes	Push-pull	CMOS	•			
TS882/4	0.21	1.1	5.5	2600	-40 to 125	Yes	Push-pull	CMOS		•	•	✓
TS880/3	0.25	0.9	5.5	2000	-40 to 125	Yes	Open drain	CMOS	•	•		
Micropower												
TS331/2/4	20	1.6	5	270	-40 to 125	Yes	Open drain	BIP	•	•	•	✓
TS7211	6	2.7	10	400	-40 to 85	Yes	Push-pull	CMOS	•			
TS7221	6	2.7	10	400	-40 to 85	Yes	Open drain	CMOS	•			
TS861/2/4	6	2.7	10	400	-40 to 85	Yes	Push-pull	CMOS	•	•	•	
TSX3702/4	5	2.7	16	340	-40 to 125	No	Push-pull	CMOS		•	•	✓
TSX393/339	5	2.7	16	550	-40 to 125	No	Open drain	CMOS		•	•	✓

Any non-automotive product may be eligible for AEC-Q100 qualification. Contact ST Sales representative for additional information.

SPEED

TS3011: rail-to-rail high-speed 5 V comparator

The **TS3011** is a single-channel comparator that boasts a high-speed response time and rail-to-rail inputs. It is designed to operate within a supply voltage range of 2.2 to 5 V and can withstand a wide temperature range from -40 to +125°C. With micropower consumption as low as just a few hundred microamperes, the TS3011 offers an excellent ratio of power consumption current versus response time. This comparator also features push-pull outputs and is available in small surface-mount device (SMD) packages, including the SOT23-5 and the SC70-5.

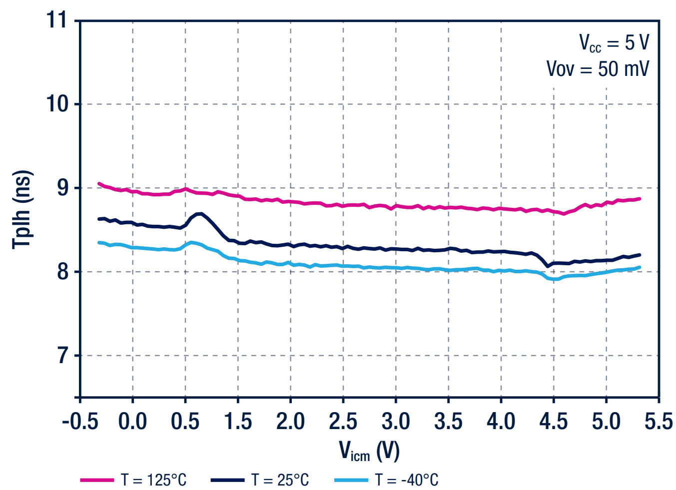
FEATURES

- Propagation delay: 8 ns
- Low current consumption: 470 µA (typ.) at 5 V
- Rail-to-rail input, push-pull output
- Supply operation from 2.2 to 5 V
- Extended temperature range: -40 to +125°C
- ESD tolerance: 2 kV HBM/200 V MM
- SMD packages
- AEC-Q100 qualified

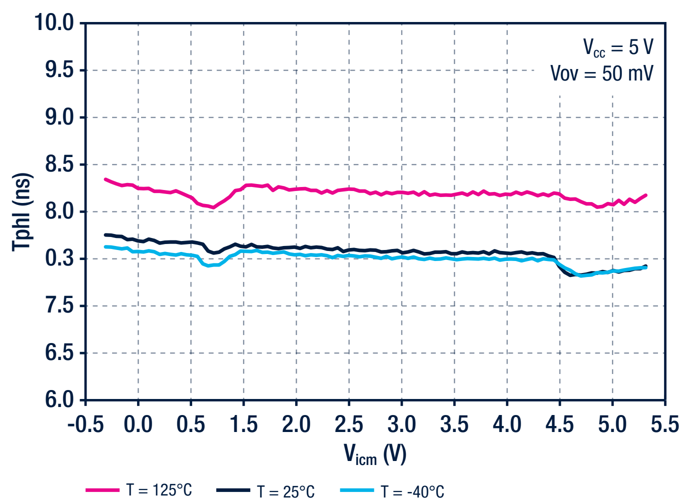
APPLICATIONS

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

Propagation delay vs. common mode voltage with negative transition



Propagation delay vs. common mode voltage with positive transition



Part number	Typ. I_{cc} per channel (µA)	Min. V_{cc} (V)	Max. V_{cc} (V)	Typ. response time (ns) 100 mV overdrive	Temperature range (°C)	Rail-to-rail in	Output type	Input type	Single	Dual	Quad	Automotive grade
Ultra high speed												
TS3011	470	2.2	5	8	-40 to 125	Yes	Push-pull	CMOS	•			✓
High speed												
TS3021/2	73	1.8	5	42	-40 to 125	Yes	Push-pull	BIP	•	•		✓

Any non-automotive product may be eligible for AEC-Q100 qualification. Contact ST Sales representative for additional information.

SMALL PACKAGES

TSX3702/4: 16 V dual and quad CMOS voltage comparators

The **TSX3702** and **TSX3704** are micropower CMOS dual- and quad-channel voltage comparators which exhibit a very low current consumption of 5 µA typical per comparator. With an improved design over the TS3704, these devices show a lower current consumption, a better input offset voltage, and an enhanced ESD tolerance. The TSX3702 and TSX3704 are fully specified over a wide temperature range and are proposed in automotive grade for the TSSOP14 and SO8 packages. They are fully compatible with the TS3702 and TS3704 CMOS comparators and are available with similar packages. The new tiny package, QFN16 (3 x 3 mm), is also proposed for the TSX3704 thus allowing even more integration on applications. Open-drain output versions are also available (TSX339 and TSX393).

FEATURES

- Low supply current: 5 µA (typ.) per comparator
- Wide single supply range 2.7 to 16 V or dual supply (±1.35 to ±8 V)
- Extremely low input bias current: 1 pA (typ.)
- Input common-mode voltage range includes ground
- Push-pull output
- High input impedance: 1012 Ω (typ.)
- Fast response time: 2.7 µs (typ.) for 5 mV overdrive
- ESD tolerance: 4 kV HBM, 200 V MM
- AEC-Q100 qualified

APPLICATIONS

- Automotive and industrial

Part number	Single	Dual	Quad	Min. V_{CC} (V)	Max. V_{CC} (V)	Typ. Response time (ns) 100 mV overdrive	Typ. I_{CC} per channel (µA)	Temp. range °C	Rail-to-rail input	Output configuration	Automotive
Small packages											
TS881	SC70-5			0.85	5.5	2000	0.21	-40 to 125	Yes	Push-pull	
TS882/4		DFN8	QFN16	1.1	5.5	2000	0.21	-40 to 125	Yes	Push-pull	✓
TS880/3	SC70-5	DFN8		0.9	5.5	2000	0.25	-40 to 125	Yes	Open drain	
TS331/2/4	SC70-5	DFN8	*	1.6	5	210	20	-40 to 125	Yes	Open drain	✓
TSX3702/4		DFN8	QFN16	2.7	16	2500	5	-40 to 125	No	Push-pull	✓
TSX393/339		DFN8	QFN16	2.7	16	900	5	-40 to 125	No	Open drain	✓
TS985	CSP			1.8	5	300	14	-40 to 85	Yes	Push-pull	
TS3011	SC70-5			2.2	5	8	470	-40 to 125	Yes	Push-pull	✓
TS3021	SC70-5			1.8	5	38	73	-40 to 125	Yes	Push-pull	✓
LM2901/3	*	DFN8		2	36	1300	250	-40 to 125	No	Open collector	✓
LMV331	SC70-5			2.7	5	200	20	-40 to 125	No	Open drain	

* Other packages are available.

HIGH OPERATING TEMPERATURE

TS3021H: rail-to-rail 1.8 V high-speed comparator

The **TS3021H** is a single-channel comparator that features high-speed response time and rail-to-rail inputs. It is designed to operate within a supply voltage range of 2 to 5 V and can withstand an extended temperature range from -40 to 150°C. With a micropower consumption as low as just a few tens of microamperes, the TS3021H offers an excellent ratio of power consumption current versus its 38 ns response time. This comparator also features push-pull outputs, and it is available in the small SOT23-5 package.

SOT23-5

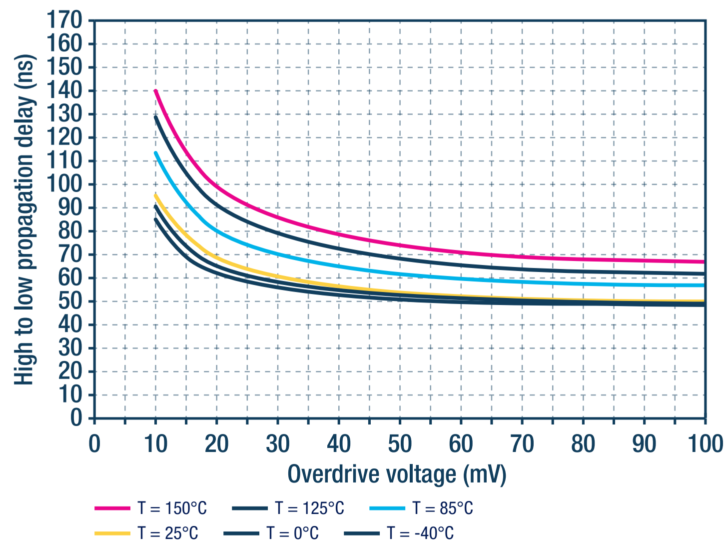
FEATURES

- Ultra-high temperature range: -40 to 150°C
- Propagation delay: 38 ns
- Low current consumption: 73 µA
- Rail-to-rail input
- Push-pull output
- Supply operation from 1.8 to 5 V
- High ESD tolerance: 5 kV (HBM) and 300 V (MM)
- Latch-up immunity: 200 mA
- SMD package
- AEC-Q100 and Q003 qualified

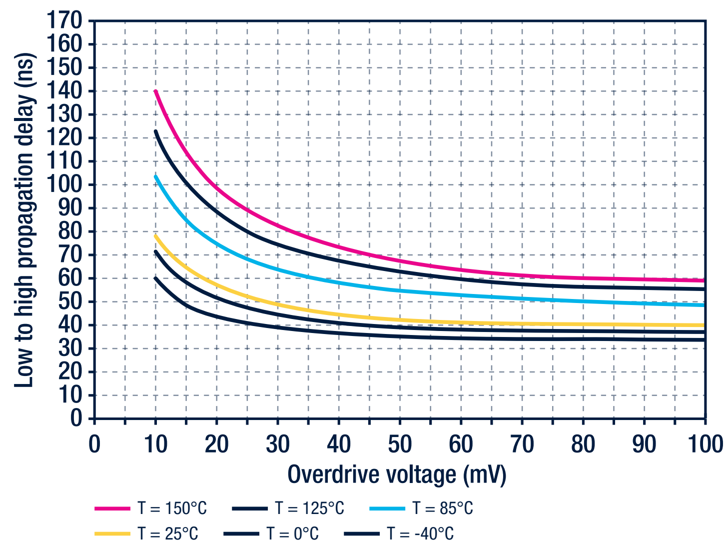
APPLICATIONS

- Automotive (gear box, exhaust, engine control, braking system,…)

Propagation delay (HL) vs. overdrive at V_{CC} = 5 V, V_{ICM} = V_{CC}



Propagation delay (LH) vs. overdrive at V_{CC} = 5 V, V_{ICM} = 0 V



Part number	Max. operating temperature (°C)	Typ. I_{CC} per channel (µA)	Min. V_{CC} (V)	Max. V_{CC} (V)	Typ. response time (ns) 100 mV overdrive	Rail-to-rail in	Output type	Single	Dual	Quad	Automotive grade
High temperature											
TS3021H	150	73	1.8	5	42	Yes	Push-pull	•			✓
LM2901H/3H	150	200	2	36	300	No	Open collector		•	•	✓
LM2903WH	150	400	2	36	500	No	Open collector		•		✓

Any non-automotive product may be eligible for AEC-Q100 qualification. Contact ST Sales representative for additional information.

Signal conditioning for pyroelectric passive infrared sensors

APPLICATION NOTE AN4368 SUMMARY

Pyroelectric passive infrared (PIR) sensors are frequently used in daily life. They are a key component for motion detection and can be used for security systems, automatic doors or automatic lights. They are commonly used to detect humans. When someone is detected in a specified area, an action can be performed such as triggering an alarm or switching the lights on in a room, for example.

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How does the sensor work?

The passive infrared sensors contain two parts that are sensitive to infrared. If both parts see the same amount of infrared light, the sensor will not detect anything. But, if one of these two parts detects more or less infrared light than the other, the sensor will trigger an output signal.

Figure 1 shows how the output voltage varies when a heat source enters or leaves an area protected by the sensor.

Figure 1: principle of PIR sensor

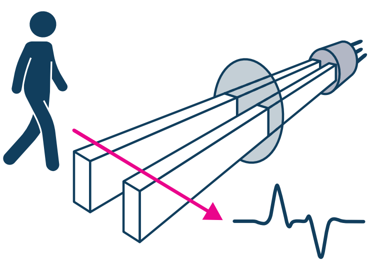
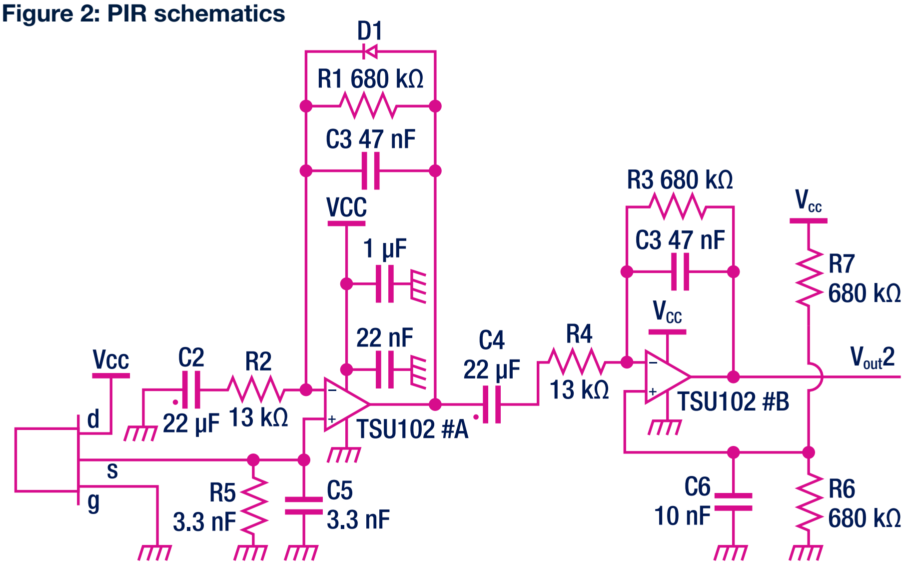


Figure 2: PIR schematics



Sensor signal conditioning

When a body with a temperature different than the ambient moves within its field of detection, the PIR sensor triggers a small AC signal in the range of 1 mVpp. Moreover, this small voltage is around a DC signal that may significantly vary from one sensor to the other. Thus, it is mandatory to cancel the DC part of the signal and to amplify only the AC part. As this signal will be disturbed by the environment, noise filtering will also be helpful.

If we want to detect human motion, we have to consider frequencies from 0.5 to 5 Hz. In this article, the amplification and filtering of this frequency range is performed thanks to the TSU102, a dual-channel op amp.

The AC signal generated by the PIR sensor is amplified by 69 dB: 35 dB thanks to the first stage and 34 dB on the second one.

The op amp's GBP must be greater than 2.7 kHz (fmax x gain x 10 = 5 x 53 x 10 = 2.7 kHz). The factor 10 has been taken into consideration in order to have some margin and to be sure not to be limited by the GBP. Almost all GBP amplifiers will fit this GBP requirement. In addition, since the DC is canceled for motion detection, the op amp's accuracy, revealed thanks to Vio parameter, has no importance. Finally, if we are dealing with portable applications, consumption is a key feature; especially since this kind of application is supplied all day. The schematic has been designed in order to optimize it.

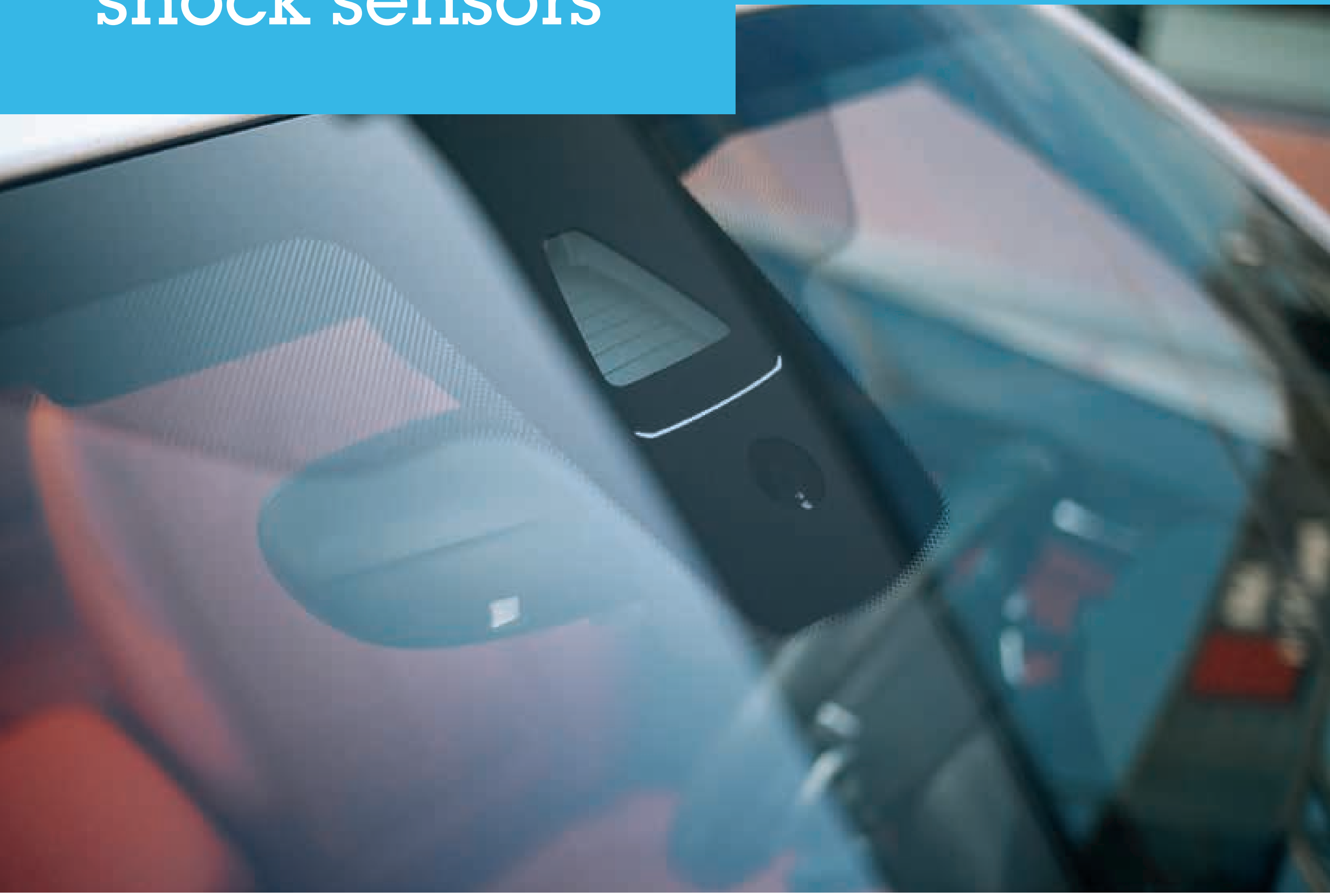
Here, the main consumption is the one due to the sensor. It consumes 19 µA. The rest of the application consumption is equal to 3.6 µA:

- 1.2 µA for the TSU102 op amp
- 2.4 µA due to the divider bridge composed by R6 and R7

CONCLUSION

Passive infrared sensors are widely used and require some op amps to amplify and to filter the signal they generate which is noisy and has a very small amplitude. A comparator can also be added to compare the amplified signal with threshold voltages before going into an I/O of the microcontroller (no need for ADC). Thanks to the TSU102, you can design an application compliant with 3.3 V microcontrollers with an optimized current consumption.

Signal conditioning for shock sensors



APPLICATION NOTE AN4708 SUMMARY

Shock sensors can be used for a wide range of applications. Considered as piezoelectric elements, they are largely used in the consumer market as hard disk drive protection, but also used in the automotive sector for security, when window glass is hit and broken. These sensors can also be used for intelligent power management to maximize battery life for tire pressure monitoring system modules integrated in tire valves.

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Charge amplifier configuration

Charge mode sensors are typically used when the electronics are connected far from the sensor. In this case, we can use the configuration shown in Figure 1. The charge amplifier requires a low bias input current as it does not charge and discharge the gain capacitor, Cf, at high currents. Consequently, it is extremely important to choose a CMOS op amp such as the TSX922, which presents a very low input current, Iib, of 10 pA @ 25°C.

If any charge coming from the piezoelectric sensor "tries" to charge the capacitance of the sensor, the cable, or the input capacitance of the amplifier, a voltage is created between the input pin of the amplifier. As the amplifier has a very high gain (90 dB), this voltage is immediately nulled by sourcing or pulling the same amount of charge through the feedback capacitance, Cf, and the resistance, Rf.

The input charge, Qs, is applied to the inverting input of the amplifier. It is distributed to the cable capacitance, Cc, the amplifier input capacitance, Cin, and the feedback capacitor, Cf.

$$Qs = QCc + QCin + QCf \quad (1)$$

By considering that Q = CV we can write

$$Qs = V_{in}(Cc + Cin) + Vf.Cf \quad (2)$$

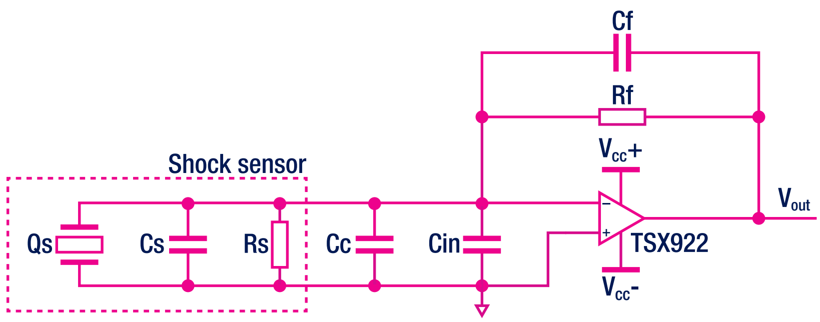
Where V_{in} is the differential voltage of the op amp and Vf the voltage in the feedback loop.

Thanks to the large gain of the op amp (AVD), and as V_{out} =-Vf, equation 2 can be simplified as equation 3:

$$V_{out} = -\frac{Qs}{Cf} \quad (3)$$

From the equation (3) we can see that charge amplifier gain is independent of input capacitance, therefore system sensitivity is unaffected by changes in input, cable length or type.

Figure 1: Charge mode amplifier configuration



Voltage amplifier configuration

For the voltage mode amplifier, the induced voltage is presented to the high impedance non inverting input and then amplified by the op amp. The main advantage of the voltage mode configuration is that the gain is set accurately with resistors rather than with a small capacitor.

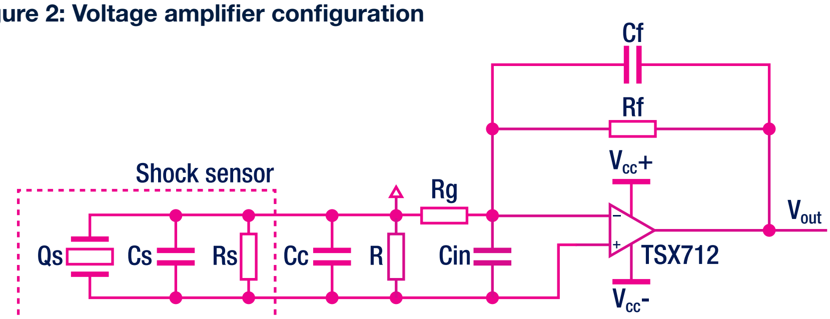
The configuration is described in Figure 2:

In a frequency range, all the charges generated by the sensor are transferred into Cs and Cc. The op amp amplifies this voltage as shown in equation 4.

$$V_{out} = -\frac{Qs}{Cs + Cc} * \left(1 + \frac{Rf}{Rg}\right) \quad (4)$$

As the gain is related to the amount of capacitance seen by the sensor, the shock sensor must be connected as close as possible to the op amp in this configuration. This is because the parasitic capacitance of the cable, Cc, affects the actual gain (and the longer the cable, the higher this capacitance). R ensure that the DC correctly biases the op amp.

Figure 2: Voltage amplifier configuration



CONCLUSION

A piezoelectric accelerometer can be used as a shock sensor with either a charge mode configuration thanks to the TSX922 or voltage mode configuration thanks to the TSX712.

Signal conditioning for NDIR sensors

APPLICATION NOTE AN5571 SUMMARY

The nondispersive infrared (NDIR) sensor is a cost-effective solution to measure a large number of different gases in the infrared (IR) range. It is largely used for carbon dioxide and hydrocarbon (HC) detection due to its reliability and simplicity of use.

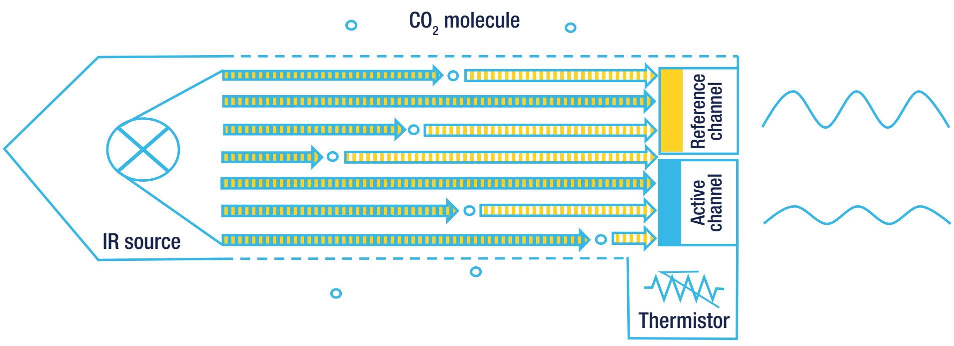
How does it work?

An NDIR can be considered a thermopile and based on the seebeck effect, which involves the conversion of heat directly into electricity at the junction of different metals.

When an infrared light hits the thermopile, its output voltage increases. The presence of a gas, however, will absorb the IR radiation, so the radiation hitting the active channel, which has a specific wavelength filter for the gas being measured, decreases and so to the output voltage. The reference channel has another wavelength filter, but still in the IR range. The ratio of the two thermopile voltages (reference and active channels) gives the concentration of gas.

Figure 1 describes the working principle.

Figure 1 Principe of NDIR sensor



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Sensor signal conditioning

An NDIR sensor provides an extremely small voltage depending on NDIR sensor application on the gas concentration. Amplifying this analog signal generally requires two amplification stages.

Some NDIR sensors have a relatively high intrinsic DC voltage, so an AC coupling architecture allows the removal of this offset.

Nevertheless, it is important to apply a reference voltage, Vref, on the second stage, firstly to correctly bias the operational amplifier, and of course to have a DC reference without any output saturation.

This can be easily achieved from the V_{cc} power supply and a divider bridge, along with a TSV632 op amp in buffer configuration.

It is also useful to monitor the Vref reference voltage with an ADC to eliminate any errors related to the resistors and operational amplifier.

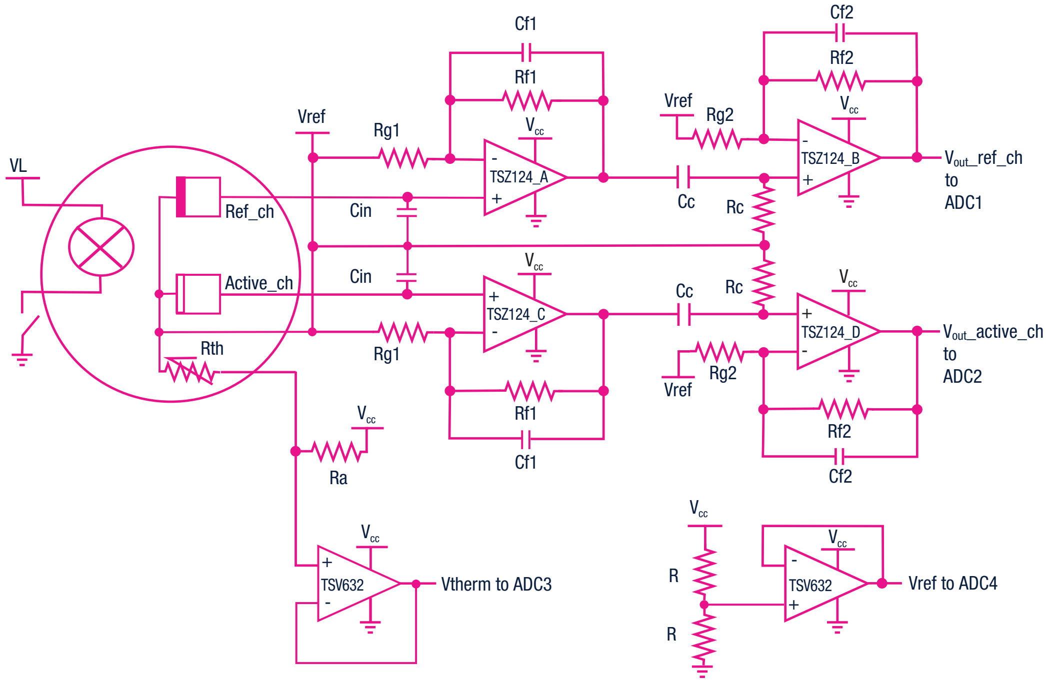
The output signal of one channel of the schematic Figure 2 can be described by:

$$V_{out} = V\,channel\left(1+\frac{Rf1}{Rg1}\right)\left(1+\frac{Rf2}{Rg2}\right)+Vref$$

Noise is a predominant error source as it cannot be calibrated and must therefore be limited as much as possible by choosing low resistances and operational amplifier with very low noise at low frequencies.

As NDIR sensors work at low frequency (a few Hz), the TSZ124 op amp is the perfect candidate to drive this sensor as it is a chopper amplifier. And contrary to traditional op amps, the TSZ124 has no 1/f noise, only 40nV/√Hz white noise, or 0.7µVpp from 0.1Hz to 10 Hz, which is generally in the range of the NDIR sensor noise.

Figure 2 Alphasense NDIR sensor application



It is also important to limit the bandwidth of the application thanks to the Rf1-Cf1 and Rf2-Cf2 network allowing a second order low pass filter.

The IR source light increases the temperature inside the cavity compared to the ambient temperature. To compensate any drift, it is important to monitor the temperature at the same time as the voltage on the active and reference channels.

The thermistor generally integrated in NDIR sensors gives the following information:

$$T\,(°C) = \frac{\beta}{\frac{\beta}{TO} + \ln\left(\frac{Ra/Ramb}{\frac{Vcc - Vref}{Vth} - 1}\right)} - 273.15$$

CONCLUSION

Nondispersive infrared (NDIR) sensors allow measurement of gas concentrations, and only two operational amplifiers are needed to condition the output sensor signal: the **TSZ124** and **TV632**. The main factor to be aware of is noise, and it is important to consider the bandwidth as well as the value of the resistances used; the smaller, the better.

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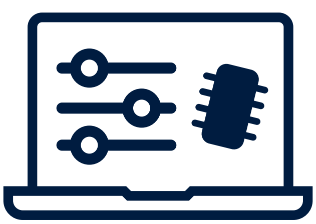

STEP 1

- Select the signal conditioning mode

STEP 2

- Select the type of product family (active analog, comparators, low and high-side current sensing)

STEP 3

- Select the desired filter performance
- Adjust your choice with different parameters (stability, efficiency, center frequency, bandwidth…)

…you can then

- Get the suggested schematics
- Get the bill of material (BOM)
- Get the different charts depending on the selected product (waveforms, efficiency, gain, phase…) in order to analyze your filter easily

- Access the datasheet
- Access the product folder
- Save and export a PSPICE model
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OP AMP NUCLEO EXPANSION BOARD

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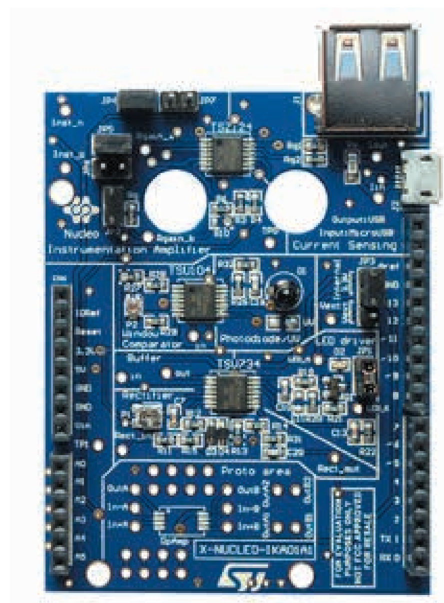
The board contains seven predefined configurations based on three different operational amplifiers:

- A TSZ124 for instrumentation amplifiers and current sensing configurations
- A TSU104 for a window comparator function or for photodiode or UV sensor configurations
- A TSV734 for LED driver and buffer configurations

Information on how to obtain the board can be found at www.st.com/x-nucleo under the reference X-NUCLEO-IKA01A1.



STM32 DEVELOPMENT SOFTWARE

Use the X-CUBE-ANALOG1 multifunctional software expansion for STM32Cube

The X-CUBE-ANALOG1 is an expansion software package for STM32Cube. The software runs on the STM32 microcontroller and is used for reading and configuring various analog functions such as instrumentation amplifier, current sensing, LED driver, photodiode/UV, and window comparator operational amplifier drivers using the TSZ124, TSV734, and TSU104 devices running on an STM32 microcontroller.

It is compatible with the X-NUCLEO-IKA01A1 expansion board plugged to a NUCLEO-F401RE, NUCLEO-F103RB, NUCLEO-L053R8, or NUCLEO-L476RG board.

STM8 Cube

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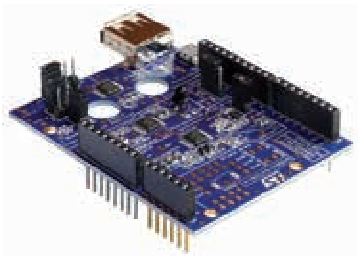
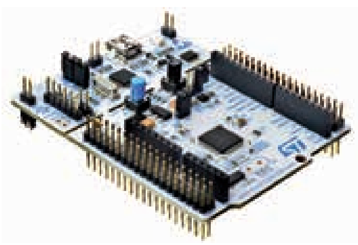


Multifunctional expansion board

Multifunctional expansion board based on operational amplifiers

ST Op Amps X-NUCLEO-IKA01A1



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Software (Free of charge)

Multifunctional software expansion X-CUBE-ANALOG1

STM32Cube

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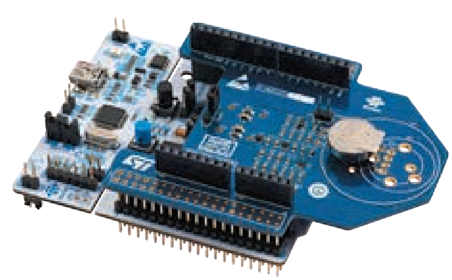
Get started with the P-NUCLEO-IKA02A1 for electrochemical toxic gas sensing



Tasteless and odorless, carbon monoxide is a highly toxic inhalant that can be lethal, which is why we need detectors to prevent intoxication risks.

The P-NUCLEO-IKA02A1 pack is a ready-to-use CO detector including an STM32 Nucleo expansion board based on two TSU111 operational amplifiers and a Figaro TGS5141 CO sensor. Two TSU111 op amps provide signal conditioning; they are ideal for electrochemical sensing thanks to their high precision and low power consumption.

Information on how to obtain the board can be found at **www.st.com/x-nucleo** under the reference P-NUCLEO-IKA02A1.

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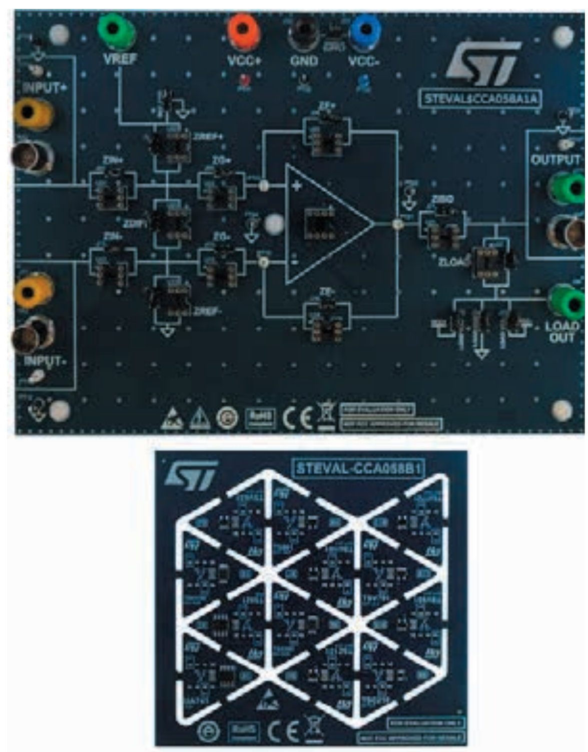

Order code	Description	Reference
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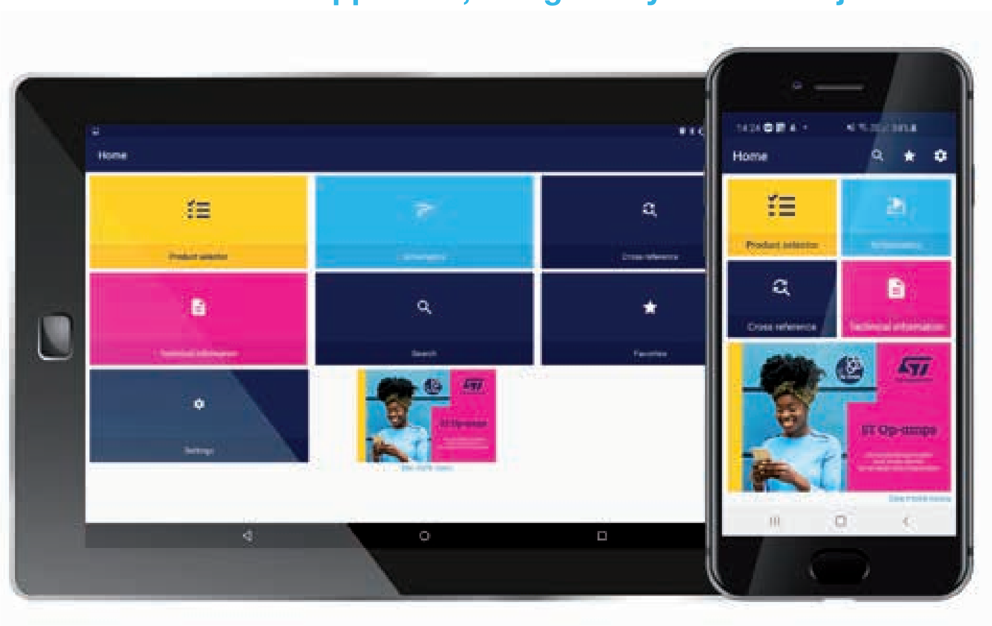

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The ST Op Amps App is available on Google Play and App Store
www.st.com/opamps-app

ST op amps naming

TSV	7	7	2	2	A	I	Y	S	T

Series root name	
TSV	High performance 5 V
TSU	Nanopower 5 V
TSZ	Zero-drift 5 V
TSX	High performance 16 V
TSB	High performance 36 V
LM	Standard amplifiers

Series root number	
1	Family specific
5	High merit factor
6	Micro power
7	High precision
9	High speed

I_{cc} and speed
Higher value means higher power consumption and faster

Compensation	
None	Standard device (unity gain stable)
9	Higher GBW (stable for gain >5)
Any	Specific to family

#opamps in package	
1	Single
2	Dual
4	Quad

With shutdown	
0	Single
3	Dual
5	Quad

Precision	
None	Standard device
A	Enhance Vio

Temperature range	
I	Industrial temperature range -40 to 125°C
H	High temperature range -40 to 150°C
H1	Very high temperature range -40 to 175°C

Grade	
None	Standard qualification
Y	Automotive grade

Package	
C	SC70
L	SOT23
Q	DFN/QFN
S	MiniSO
P	TSSOP
D	SO

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