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.

ST Op Amps

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

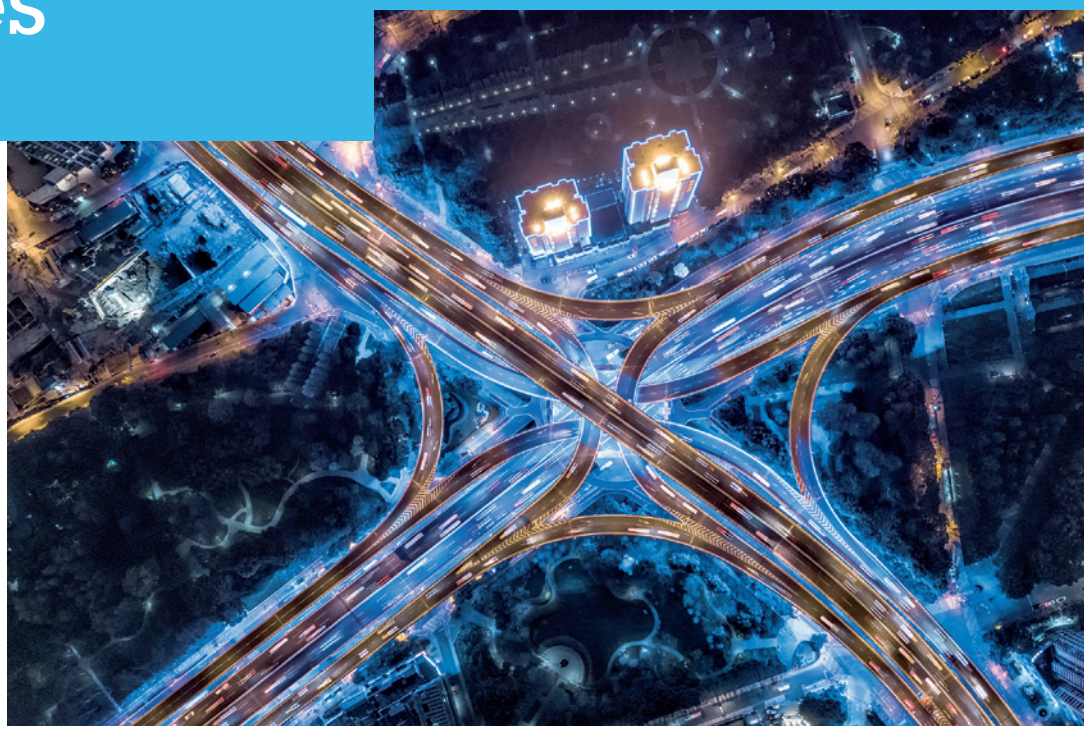
Small packages

High temperature

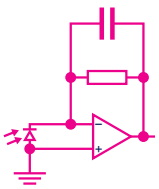
Automotive

Application schematics examples

SIGNAL CONDITIONING FOR ENVIRONMENTAL MONITORING AND DETECTION

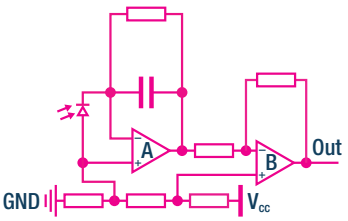


Photodiode current sensing



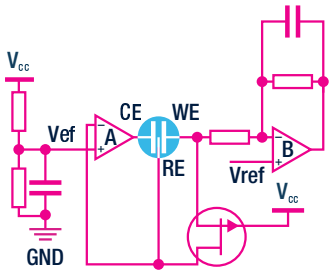
FEATURED PRODUCTS:
- TSU series
- TSX series
- TSV63 series
- TSV7 series

Smoke detector



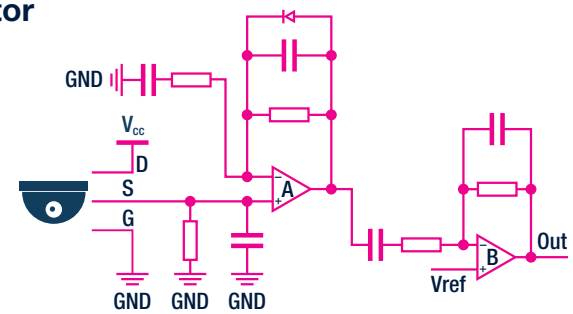
FEATURED PRODUCTS:
- TSV629 series
- TSV5 series
- TSV7 series

CO detector



FEATURED PRODUCTS:
- TSU series
- TSZ series

PIR detector

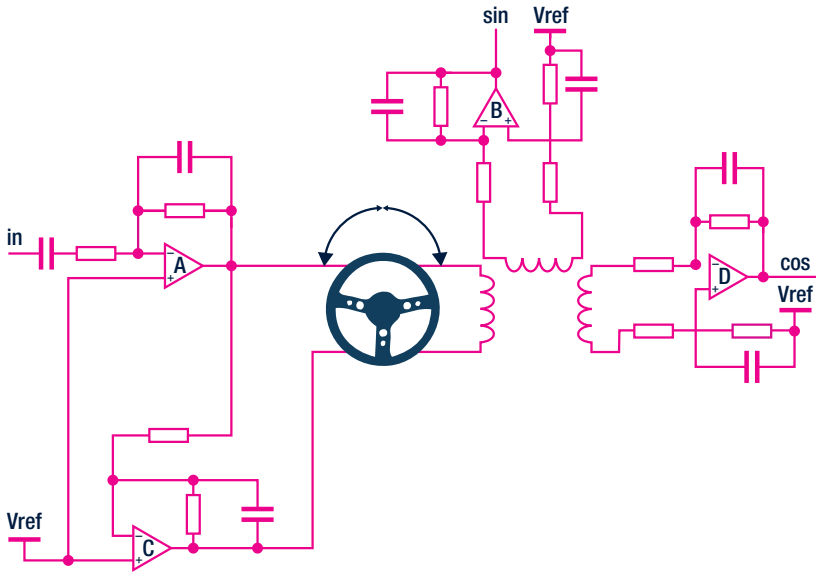


FEATURED PRODUCTS:
- TSU series
- TSZ series

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

SIGNAL CONDITIONING FOR AUTOMOTIVE CONTROL AND MONITORING

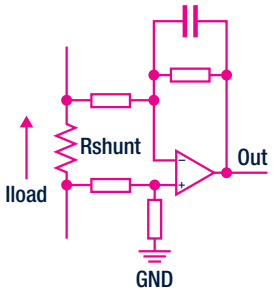
Steering angle sensor



FEATURED PRODUCTS:

- TSX564IYPT
- TSX922IYDT
- TSB582IYDT
- TSB514IYPT

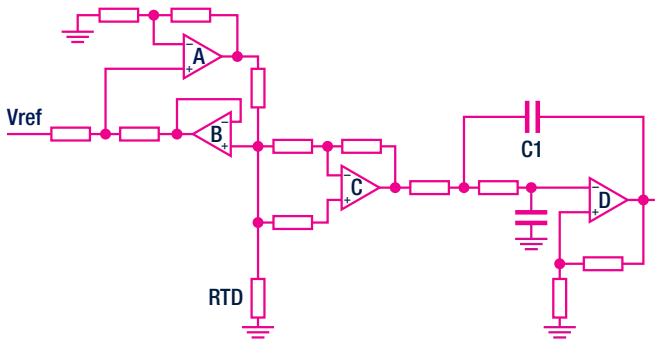
Current measurement



FEATURED PRODUCTS:

- TSV7 series
- TSZ series
- TSX7 series
- TSX9 series

Resistance temperature detector



FEATURED PRODUCTS:

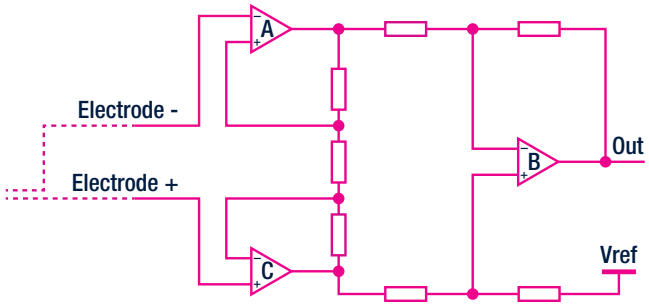
- TSZ124IYPT

KEY PARAMETERS

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

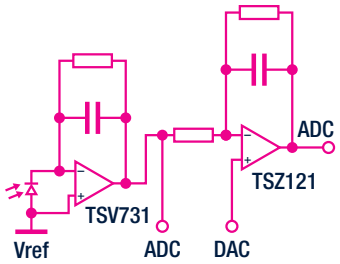
SIGNAL CONDITIONING FOR REMOTE HEALTH MONITORING AND MANAGEMENT

Electrocardiography (ECG)



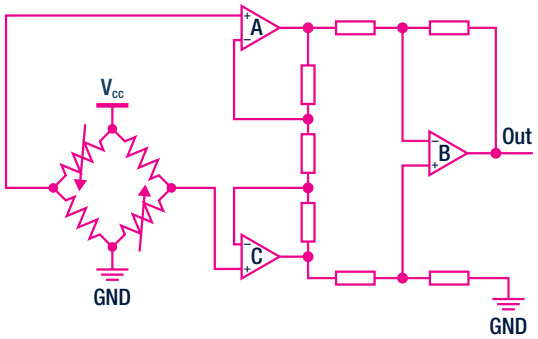
FEATURED PRODUCTS:
- TSZ series

Pulse oximeter sensor



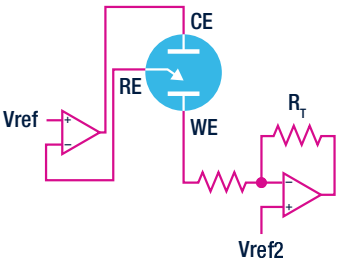
FEATURED PRODUCTS:
- TSZ series
- TSV7 series

Blood pressure sensor



FEATURED PRODUCTS:
- TSV7 series
- TSZ series

Glucose meter

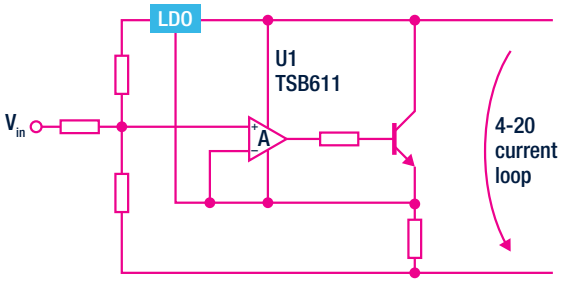


FEATURED PRODUCTS:
- TSV6 series
- TSV7 series

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

SIGNAL CONDITIONING FOR INDUSTRIAL PROCESS CONTROL AND MONITORING

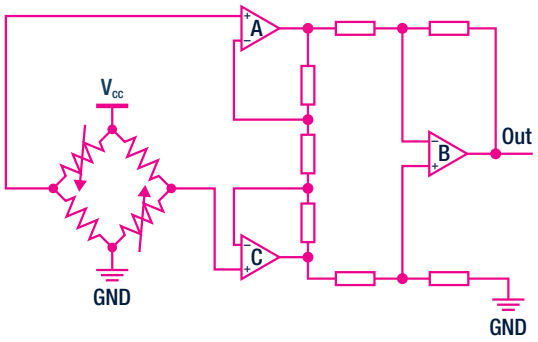
4-20 mA current loop



FEATURED PRODUCTS:

- TSB5 series
- TSB6 series
- TSX7 series

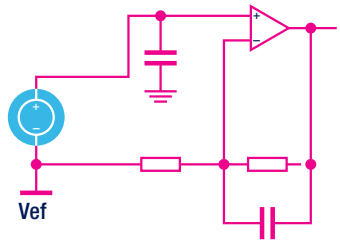
Force/pressure (strain gauge)



FEATURED PRODUCTS:

- TSZ124IYPT

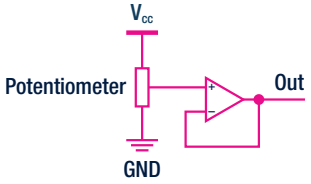
Thermopile



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.

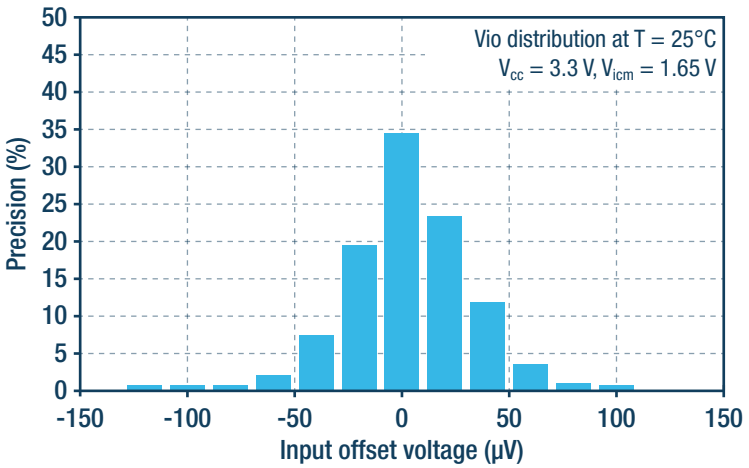
FEATURES

- 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
- Packages: DFN6, DFN8, MiniSO8, QFN16, SC70-5, and TSSOP14

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



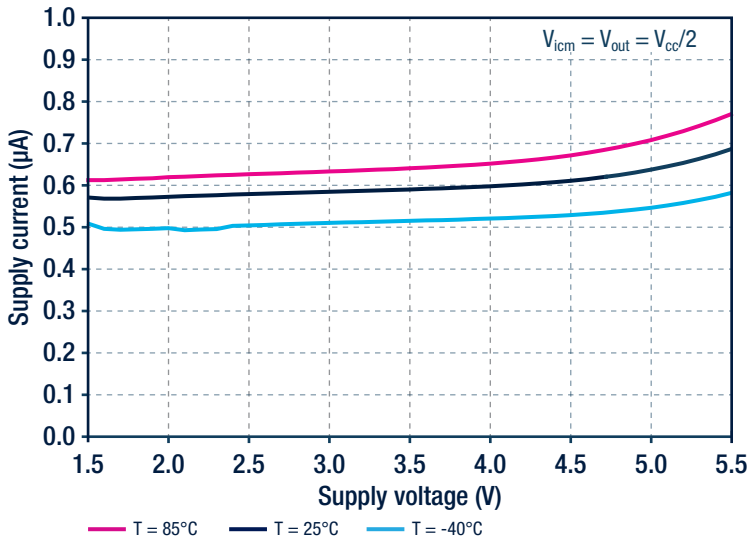
TSU10 series: nanopower (580 nA), rail-to-rail input and output, 5 V CMOS

The **TSU10** series 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

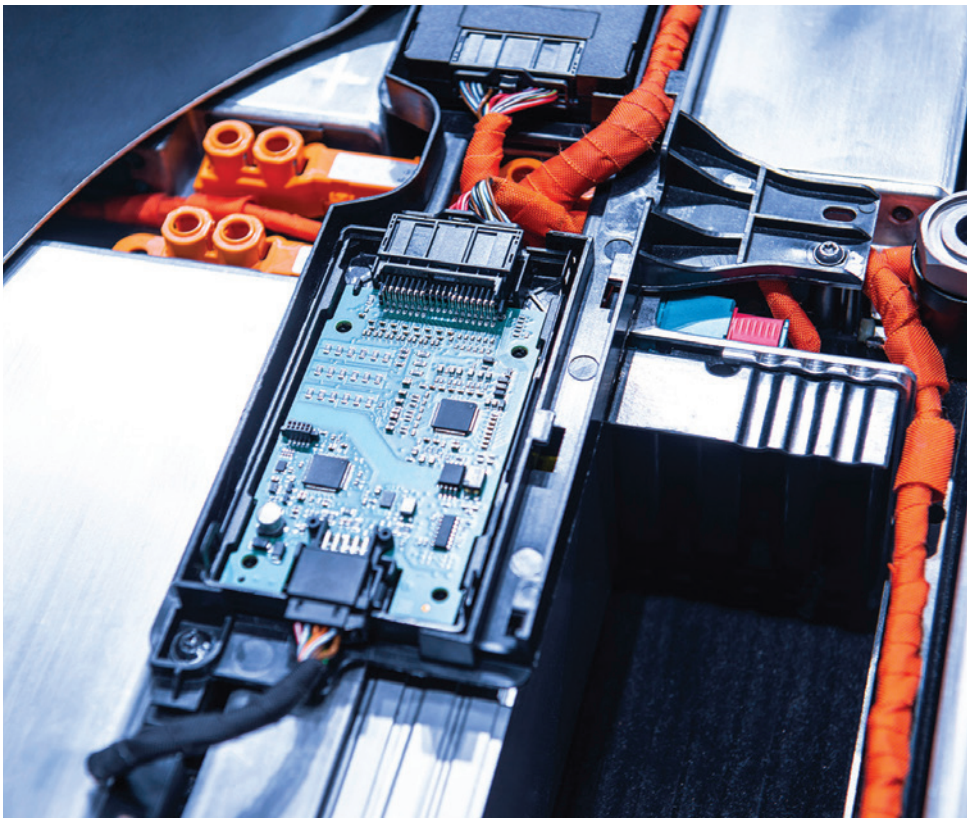


FEATURES

- 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
- Packages: DFN8, MiniSO8, QFN16, SC70-5, SOT23-5, and TSSOP14

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} ≤ 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} ≤ 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	•	•	•	✓
TSZ151/2	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 ultralow input bias current. These characteristics make this series particularly well-suited for high-accuracy, high-bandwidth sensors.

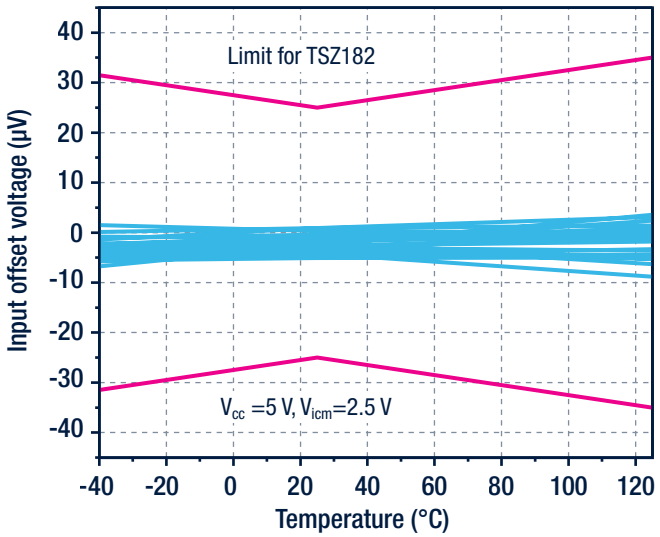
FEATURES

- 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
- Packages: DFN6, DFN8, MiniSO8, SOT23-5, and SO8

APPLICATIONS

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

Input offset voltage vs. temperature



TSZ151/2: very high accuracy (7 µV), high bandwidth (1.6 MHz), zero-drift 5 V

The **TSZ15** series consists of single and dual- channel operational amplifiers designed to deliver very low offset voltages with nearly zero-drift in response to temperature variations. These amplifiers feature railto-rail input and output, offering an excellent speed-to-power consumption ratio, with a gain bandwidth product of 1.6 MHz, all while consuming a mere 210 µA at 5 V.

Additionally, this series boasts an ultralow 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
- Packages: DFN8, MiniSO8, SC70-5, SOT23-5, and SO8

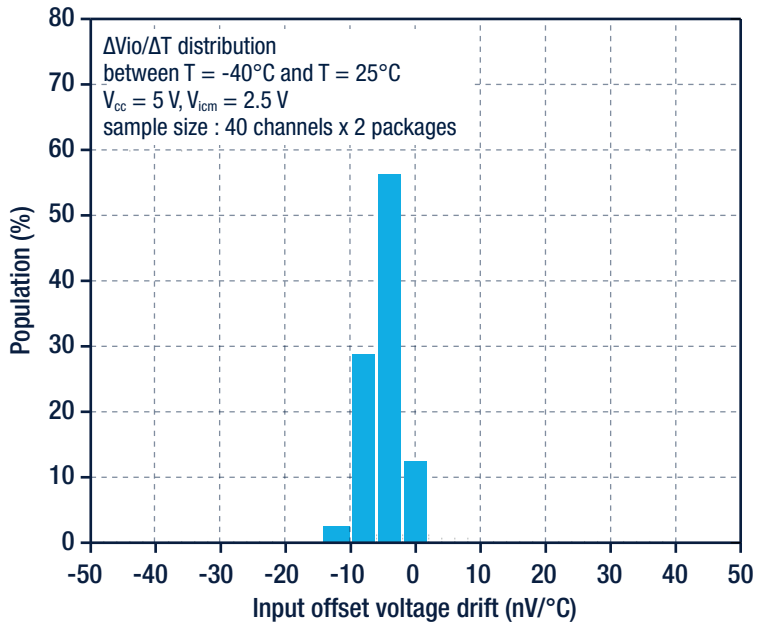
BENEFITS

- 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)



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	•	•	•	✓
TSZ151/2	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 to 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.

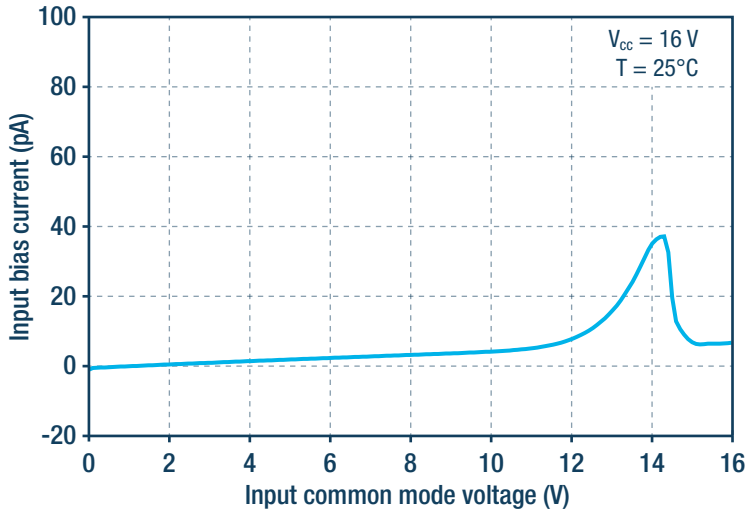
FEATURES

- 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
- Packages: MiniSO8, SOT23-5, and SO8

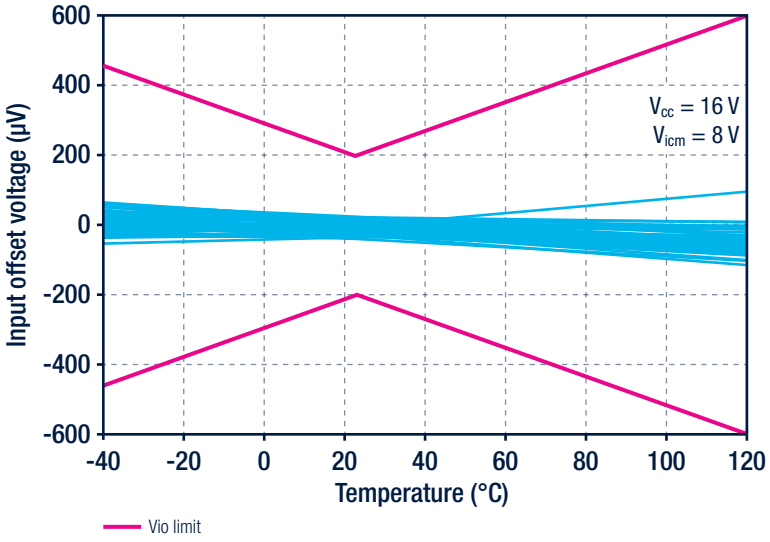
APPLICATIONS

- 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	•			✓
TSB951/2	50	3000	4.5	36	52	30	2600	16	No	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	•	•		✓
TSZ151/2	200	7	1.8	5.5	1.3	0.8	300	27	Yes	Yes	•	•		✓

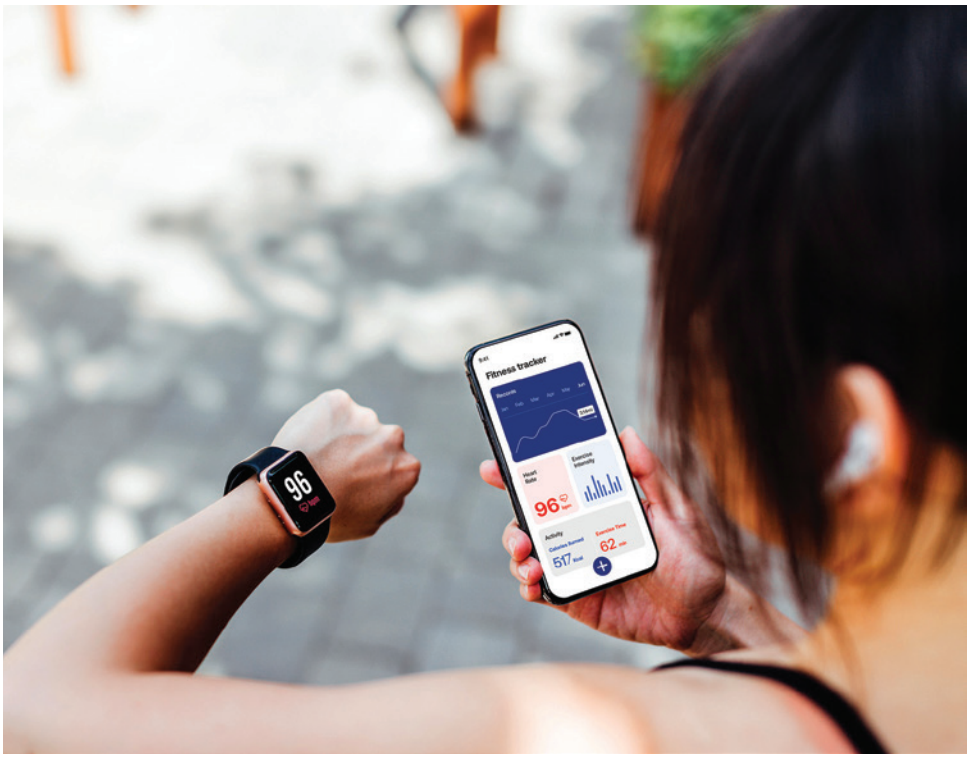
Any non-automotive product may be eligible for AEC-Q100 qualification. Contact ST sales representative for additional information.

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 ultralow 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.



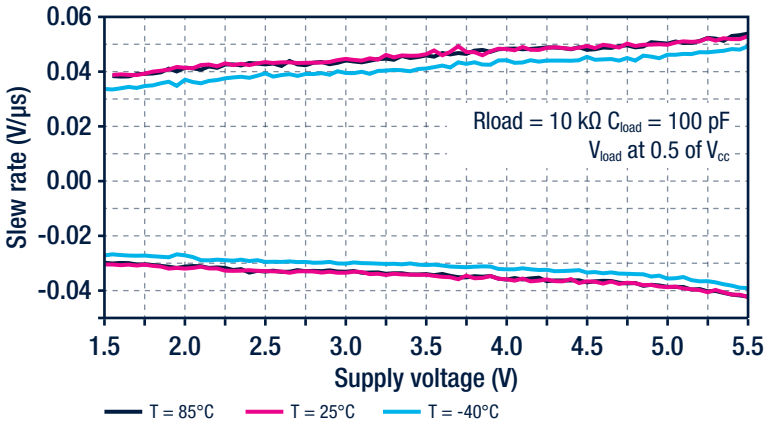
FEATURES

- 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.)
- Packages: MiniSO8, SC70-5, SOT23-5, and SO8

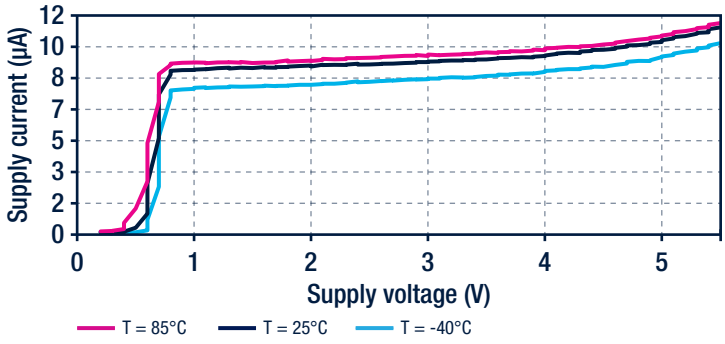
APPLICATIONS

- 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	•	•	•	✓
TSZ151/2	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.

TSB181/2: very high accuracy (20 µV), zero-drift, rail-to-rail output, 3 MHz, 36 V

The **TSB18** series consists of a single and dual operational amplifiers that provide very high precision with a maximum input-offset voltage of 20 µV. They have an extended supply voltage range up to 36 V and features rail-to-rail output. These amplifiers offer an excellent speed/current consumption ratio with a gain bandwidth product of 3 MHz, typically consuming 650 µA per operational amplifier over a wide supply voltage range. This series 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 their small package size, these devices can be used in applications where board space is limited, reducing the overall cost of the PCB.

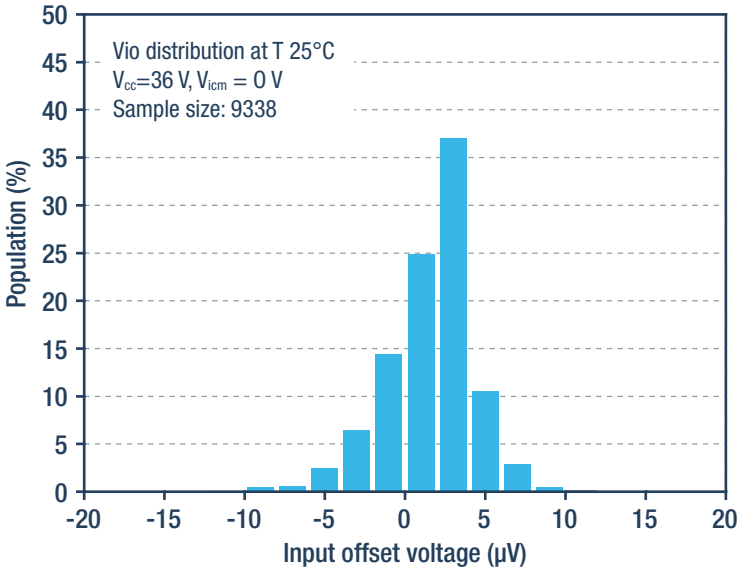
FEATURES

- 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
- Packages: MiniSO8, SOT23-5, and SO8

APPLICATIONS

- Automotive, industrial, power supplies

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



TSB951/2: high-speed, rail-to-rail output, extended supply voltage range

The **TSB9** series consists of high-speed operational amplifiers, featuring a wide supply voltage range up to 36 V, and rail-to-rail output. They offer a high gain bandwidth product of 52 MHz while consuming only 3.3 mA per channel. These amplifiers are ideal for industrial and automotive applications, operating reliably across a temperature range of -40° to +125°C. Their compact size makes them suitable for space-constrained designs, reducing overall PCB costs.

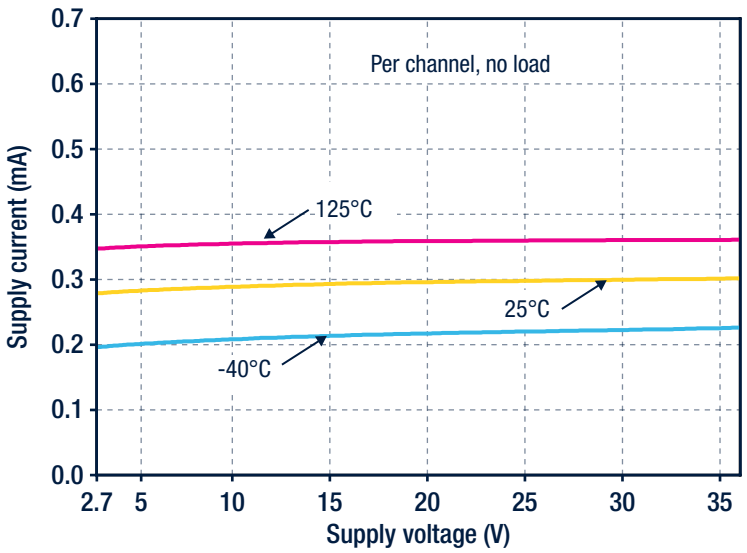
FEATURES

- Low current consumption: 3.3 mA max. per channel at V_{cc} = 36 V
- Wide supply voltage: 4.5 to 36 V
- High gain bandwidth: 52 MHz
- Rail-to-rail output
- High ESD tolerance: 4 kV HBM
- Extended temperature range: -40 to +125°C
- Automotive qualification
- Micropackages: DFN8 3x3 wettable flank, SOT23-5, and SO8

APPLICATIONS

- Industrial
- Automotive
- Space-constrained applications

Supply current vs. supply voltage



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		Single	Dual	Quad	Automotive grade
							In	Out				
TSB951/2	36	4.5	52	3000	2600	40	No	Yes	•	•		✓
TSB181/2	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

TSV79 series: 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.

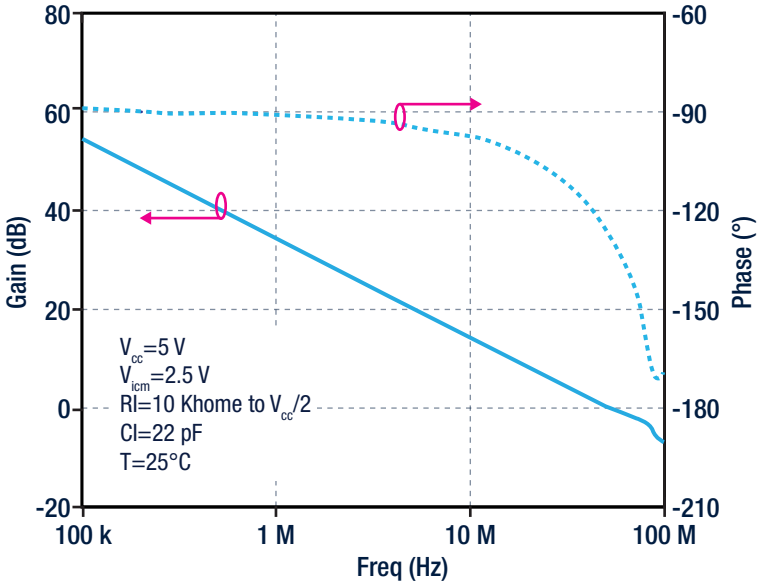
FEATURES

- 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
- Packages: DFN8, MiniSO8, SO8, SO14, SOT23-5, and TSSOP14

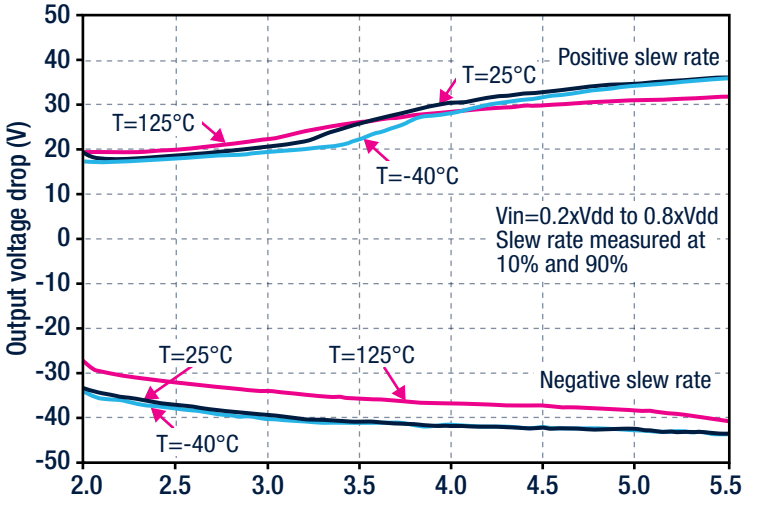
APPLICATIONS

- 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	•	•	•	✓
TSB951/2	52	30	2600	4.5	36	3000	16	40	No	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

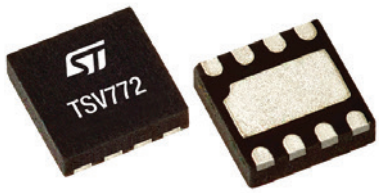
The **TSV772IQ2T** is a unity-gain-stable amplifier with a bandwidth of 20 MHz. It is a dual amplifier with a rail-to-rail input stage and a slew rate of 10.5 V/µs, making it ideal for low-side current measurement. This device provides excellent accuracy with a maximum input voltage of 200 µV, allowing 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

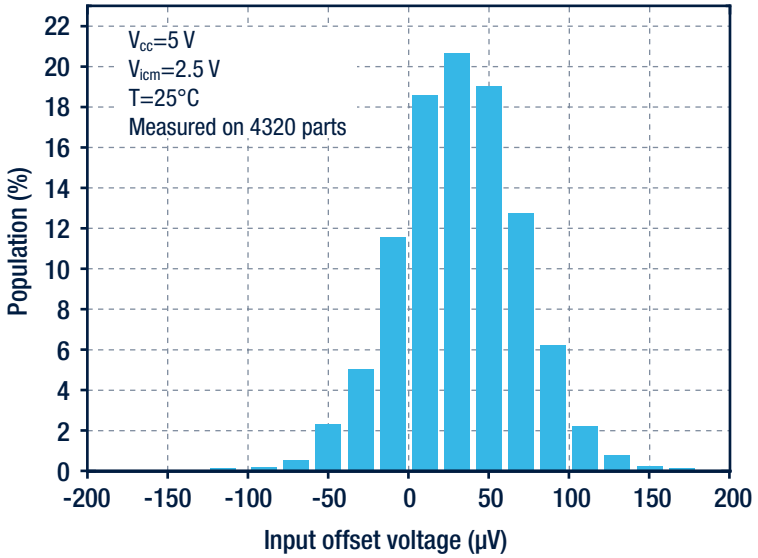
APPLICATIONS

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

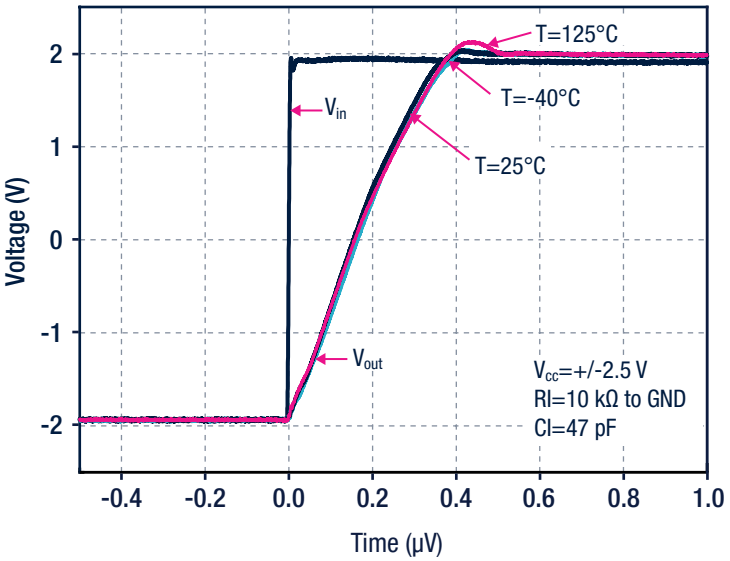


DFN8

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	✓
TSB951/2	*	DFN8		4.5	36	52	2600	3000	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	✓
TSZ151/2	SC70-5	DFN8		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

TSB57 series: low-power, 2.5 MHz, rail-to-rail input and output, 36 V

The **TSB57** series consists of single- and dual-channel operational amplifiers providing an extended voltage operating range from 4 to 36 V and rail-to-rail input/output. These amplifiers offer 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. This series is stable and robust, making it an ideal solution for a wide range of applications requiring an extended operating voltage.

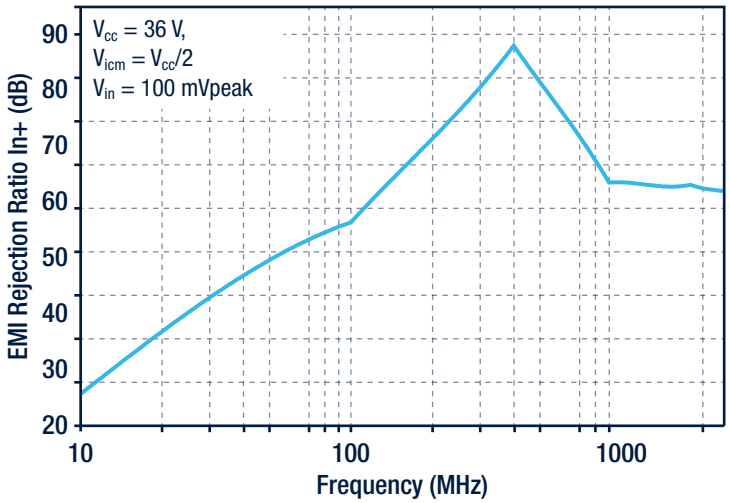
FEATURES

- 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
- Packages: DFN8, MiniSO8, SOT23-5, and SO8

APPLICATIONS

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

EMI rejection ratio V_{cc} = 36 V



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		Single	Dual	Quad	Automotive grade
								In	Out				
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	800	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.

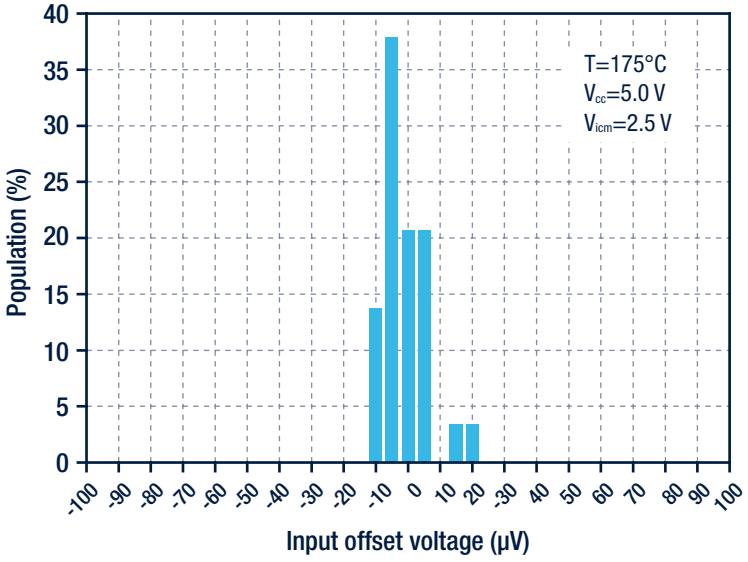
FEATURES

- 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

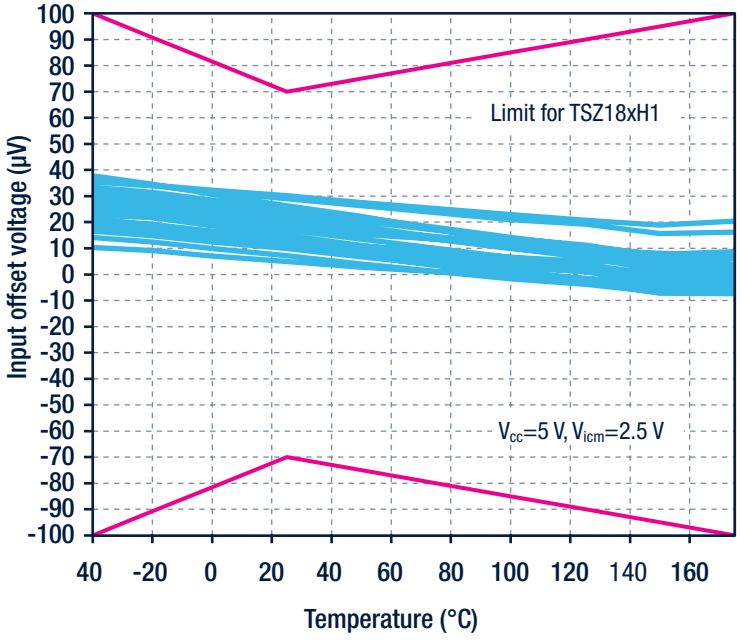
APPLICATIONS

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

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



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: OP AMPS, CLASS AB, CLASS D, AND HEADPHONE AMPLIFIERS

TS97 series: 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.

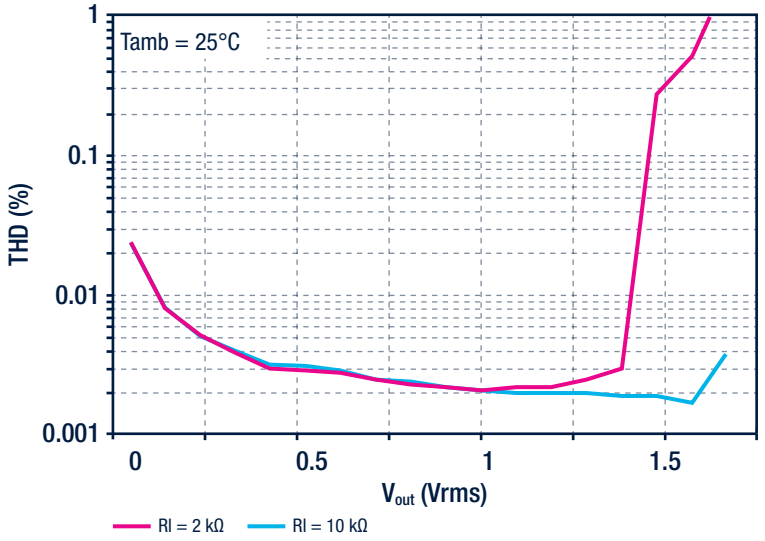
FEATURES

- Rail-to-rail output voltage swing ±2.4 V at V_{CC} = ±2.5 V
- Very low noise level: 4 nV/√Hz
- Ultralow 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)
- Packages: SOT23-5L, SO8, TSSOP8, DFN8, SO14, TSSOP14

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		•	•

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

CURRENT-SENSE AMPLIFIERS

TSC2020/21/22: precision, bidirectional current sense amplifiers with a wide range of common mode voltages

The **TSC2020/TSC2021/TSC2022** are a series of bidirectional current sense amplifiers that provide precise measurement of current via a shunt resistor. They can sense current over a wide range of common mode voltages, from -4 to +100 V, regardless of the supply voltage. Moreover, they can sense very low drop voltages, minimizing measurement errors.

These devices may be used in various applications, including precision current measurement, overcurrent protection, current monitoring, and feedback loops. They fully operate over the supply voltage range of 2.7 to 5.5 V and over the temperature range of -40 to 125°C.

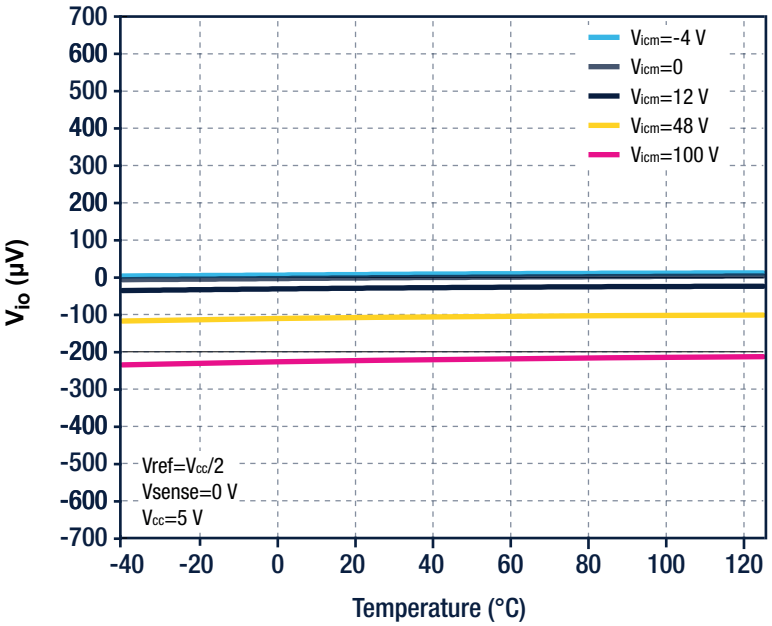
FEATURES

- 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:
  - TSC2020 20 V/V
  - TSC2021 50 V/V
  - TSC2022 100 V/V
- Gain error: 0.3% max.
- Gain drift: 3.5 ppm/°C max.
- Packages: MiniSO8, SO8, and TSSOP8
- 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



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	✓
TSC2020/21/22	Bidirectional	0.15	2300	-4	100	2.7	5.5	20, 50, 100	-40	125	SO8, MiniSO8, TSSOP8	✓
TSC2010H/2011H/2012H	Bidirectional	0.2	1500	-20	70	2.7	5.5	20, 60, 100	-40	150	SO8	✓
TSC1801	Bidirectional	0.2	3600	-0.1	3.5	2	5.5	20	-40	125	SOT23-6L	✓

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 TSC210/13	DB4471
STEVAL-AETKT3V1	Evaluation kit for high voltage current sense amplifier with comparator based on the TSC200/201/202	DB5190
STEVAL-AETKT4V1	Evaluation kit for high voltage, precision current sense amplifier based on the TSC2020/21/22	DB5336

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 ultralow 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.

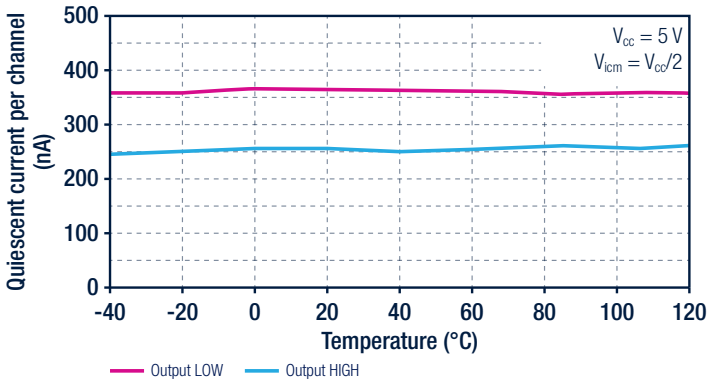
FEATURES

- 900 nA per channel at 25°C
- Ultralow 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

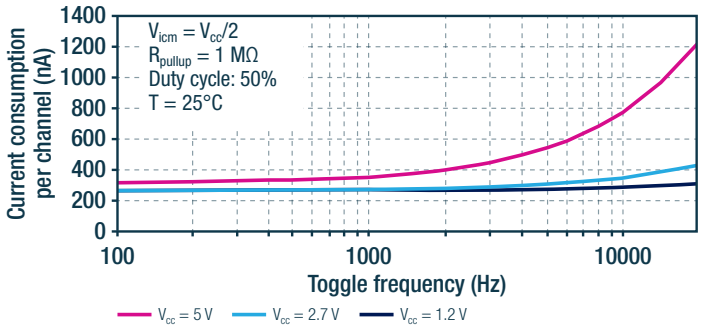
APPLICATIONS

- 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.

HIGH SPEED

TS3121/TS3121A: rail-to-rail, open-drain comparator with embedded fail-safe input/output

The **TS3121** and **TS3121A** are high-speed, low-power comparators with a propagation delay of 60 ns.

They feature a fail-safe architecture that allows input/output pins to be biased even when the supply pin is at 0 V, making them ideal for energy-saving applications. These comparators operate over a wide supply voltage range of 1.7 to 5.5 V.

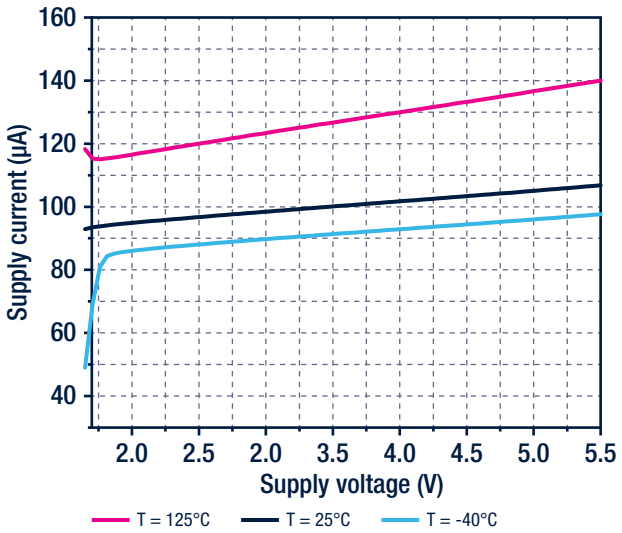
FEATURES

- Low offset voltage: 2 mV max. @ 25°C (A grade version)
- Low power c onsumption: 70 µA (typ.)
- Fast propagation delay: 60 ns
- Wide supply voltage: 1.7 to 5.5 V
- Rail-to-rail input
- Open-drain output
- Extended temperature range: -40 to +125°C
- High ESD tolerance: 4 kV HBM
- Fail-safe input/output pins
- AEC-Q100 qualified
- Packages: SC70-5, SOT23-5

APPLICATIONS

- Industrial
- Automotive systems
- Power tools
- Overcurrent and threshold detection

Supply current vs. supply voltage at $V_{icm} = V_{CC}$, output high



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	38	-40 to 125	Yes	Push-pull	BIP	•	•		✓
TS3121/A	70	1.7	5.5	60	-40 to 125	Yes	Open-drain	CMOS	•			✓

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.

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: 10^{12} Ω (typ.)
- Fast response time: 2.7 µs (typ.) for 5 mV overdrive
- ESD tolerance: 4 kV HBM, 200 V MM
- AEC-Q100 qualified
- Packages: DFN8, MiniSo8, QFN16, SO8, SO14, TSSOP8, and TSSOP14

APPLICATIONS

- Automotive and industrial

Part number	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	Single	Dual	Quad	Automotive
Small packages											
TS881	0.85	5.5	2000	0.21	-40 to 125	Yes	Push-pull	SC70-5			
TS882/4	1.1	5.5	2000	0.21	-40 to 125	Yes	Push-pull		DFN8	QFN16	✓
TS880/3	0.9	5.5	2000	0.25	-40 to 125	Yes	Open drain	SC70-5	DFN8		
TS331/2/4	1.6	5	210	20	-40 to 125	Yes	Open drain	SC70-5	DFN8	QFN16	✓
TSX3702/4	2.7	16	2500	5	-40 to 125	No	Push-pull		DFN8	QFN16	✓
TSX393/339	2.7	16	900	5	-40 to 125	No	Open drain		DFN8	QFN16	✓
TS985	1.8	5	300	14	-40 to 85	Yes	Push-pull	CSP			
TS3011	2.2	5	8	470	-40 to 125	Yes	Push-pull	SC70-5			✓
TS3021	1.8	5	38	73	-40 to 125	Yes	Push-pull	SC70-5			✓
TS3121/A	1.7	5.5	60	70	-40 to 125	Yes	Open drain	SC70-5			✓
LM2901/3	2	36	1300	250	-40 to 125	No	Open collector	*	DFN8		✓
LMV331	2.7	5	200	20	-40 to 125	No	Open drain	SC70-5			

* Other packages are available.

HIGH OPERATING TEMPERATURE COMPARATORS

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.

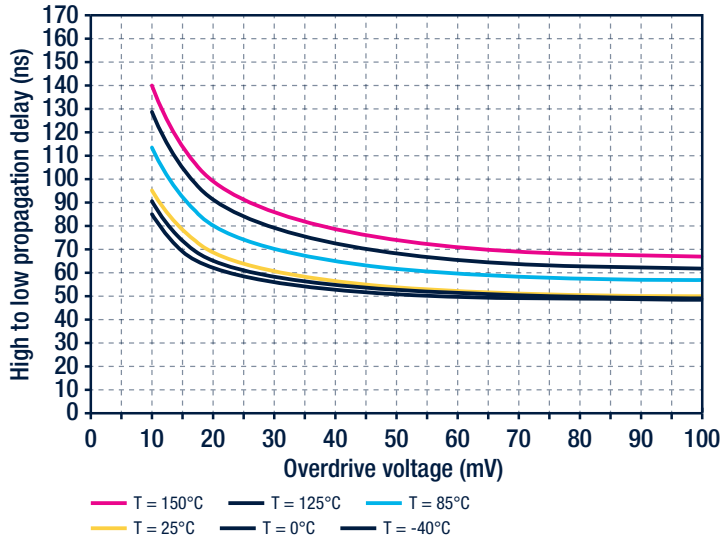
FEATURES

- 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

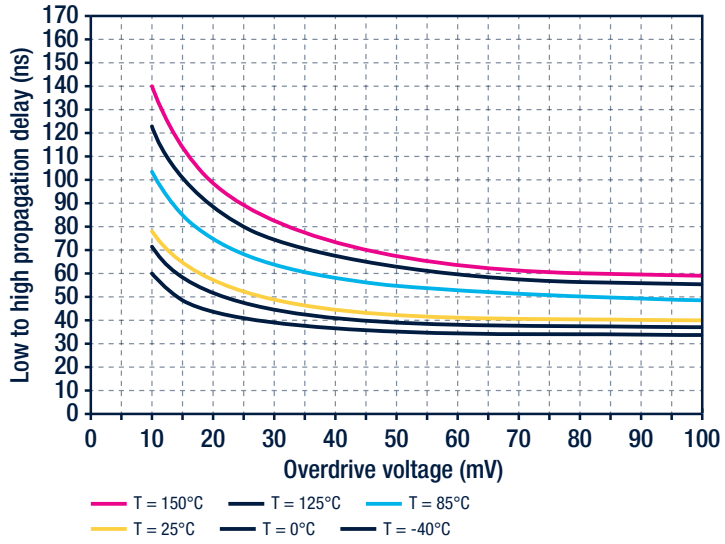
APPLICATIONS

- 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	38	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.

DOWNLOAD AN4368

www.st.com

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

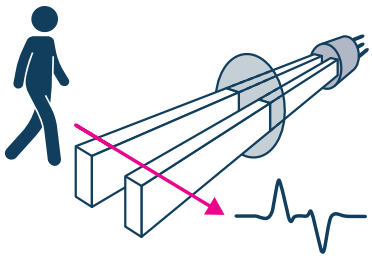
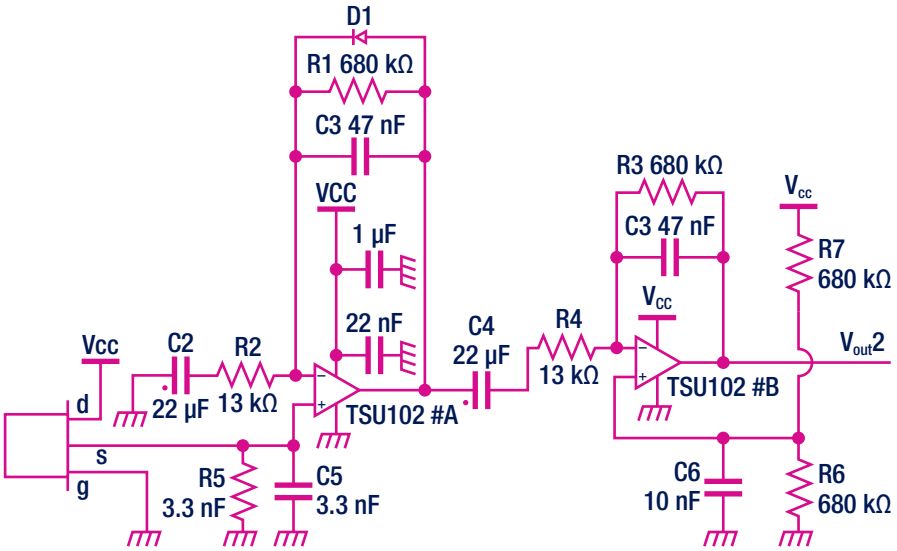


Figure 2: PIR schematics



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.

DOWNLOAD AN4708

www.st.com

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

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

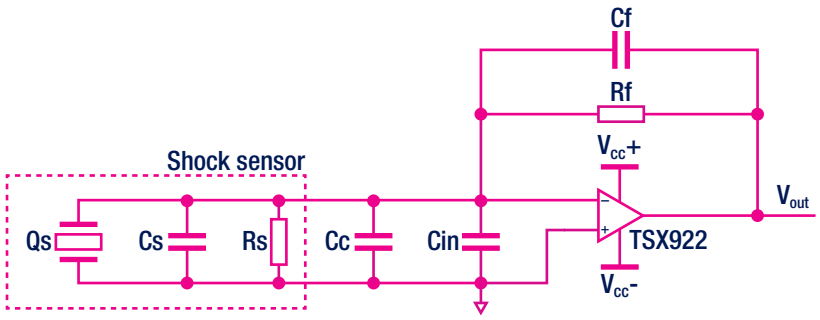
Where V_{in} is the differential voltage of the op amp and Vf the voltage in the feedback loop.

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.

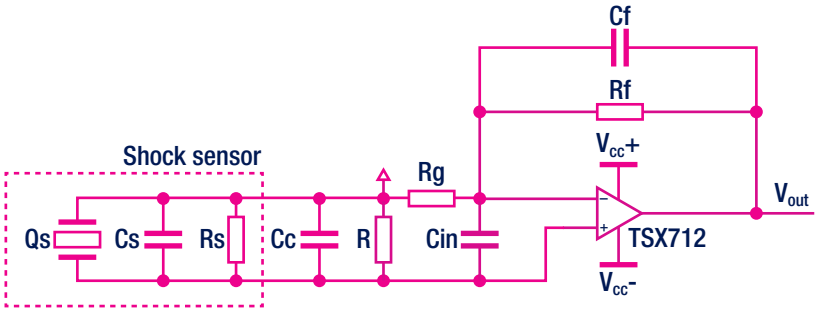
The configuration is described in Figure 2:

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.

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

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.

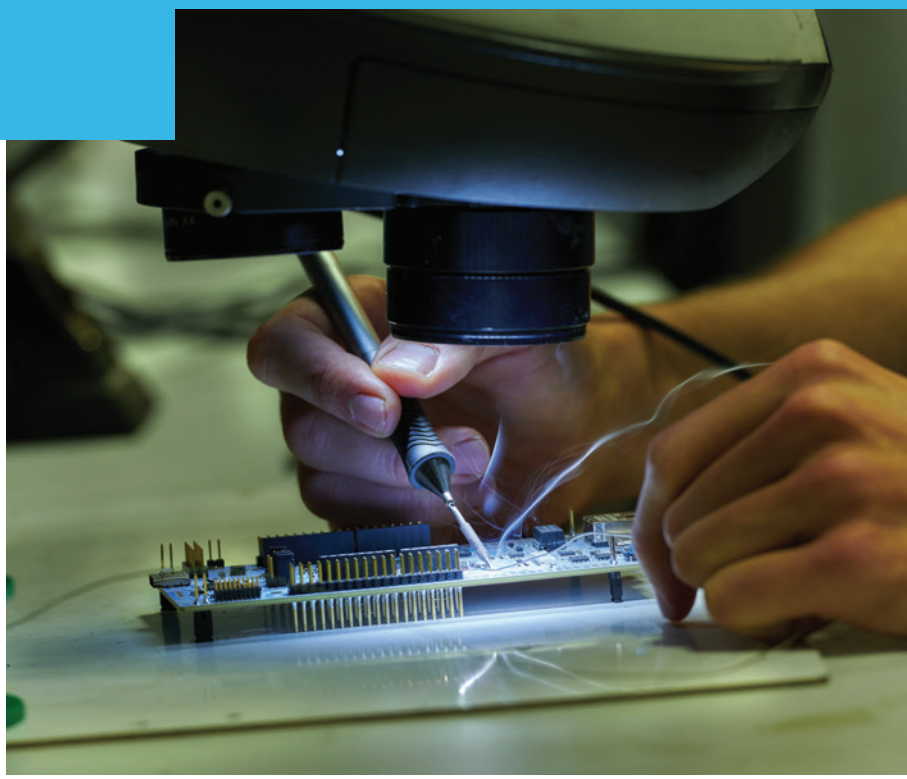
Figure 2: Voltage amplifier configuration



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.

How to design and implement overcurrent protection circuits



Application note AN6236 summary

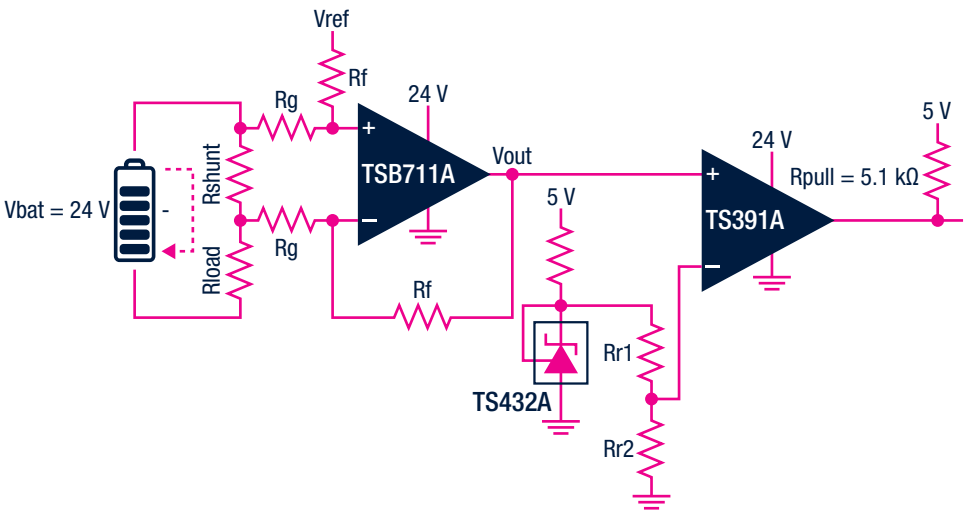
Current measurement is very important in any electronic system, to prevent damage by quickly and accurately detecting current variations. Traditional overcurrent protection method is the well-known fuse. However, modern solutions use op amps or current sensing techniques to measure and amplify the current through a shunt resistor, and comparators to trigger events. These advanced methods provide more accurate overcurrent detection and allow for reusable protection once the fault is cleared.

Op amp and comparator

The most cost-effective option for building an overcurrent protection (OCP) function involves using an off-the-shelf op amp and comparator. In a high-side overcurrent protection application, see fig 1, the first stage is realized using a rail-to-rail TSB711A op amp and four external gain resistors, which act as a current sensor. The output voltage of this stage gives a linear response to the current flowing through the shunt resistor, following the equation:

$$V_{out} = I_{load} * R_{shunt} * \frac{Rf}{Rg} + Vref$$

Figure 1 OCP function with an op amp and comparator



DOWNLOAD AN6236

www.st.com

The reference voltage (Vref) shifts the output voltage to avoid saturation when the current is low or zero.

The second stage is realized with a TS391A comparator and a TS432A reference voltage. This stage triggers the overcurrent event when the current sensing output voltage exceeds a set threshold voltage (Vtrip). The triggering voltage is given by:

$$V_{trip} = I_{max} * R_{shunt} * \frac{Rf}{Rg} + Vref - Overdrive$$

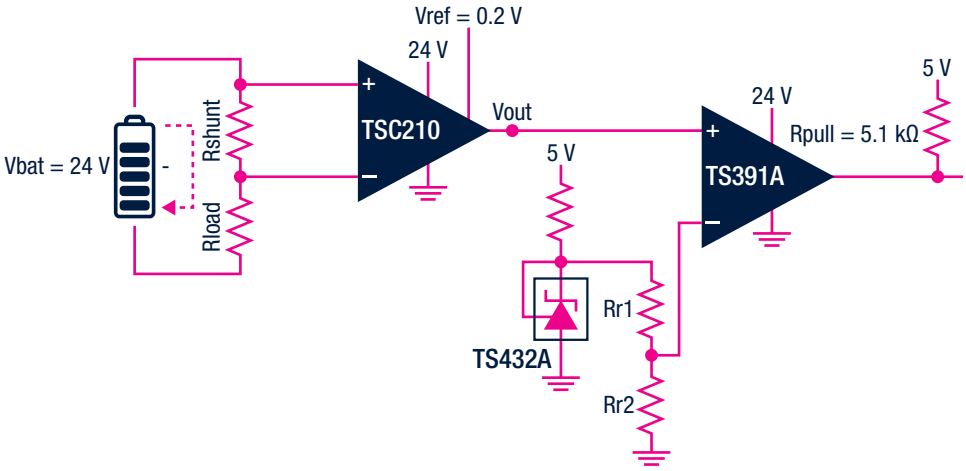
The highest overdrive ensures the best response time for the comparator.

To maximize cost reduction, a voltage divider can be used instead of the reference voltage to set the comparator's triggering voltage.

Current sensing and comparator

In the same approach as previously described, the op amp TSB711A can be replaced with the current sensing amplifier TSC210. See fig 2. One of the main advantages of using the TSC210 is that it integrates the gain resistors, which allows for better precision and saves PCB area.

Figure 2 OCP function with a current sensing and a comparator

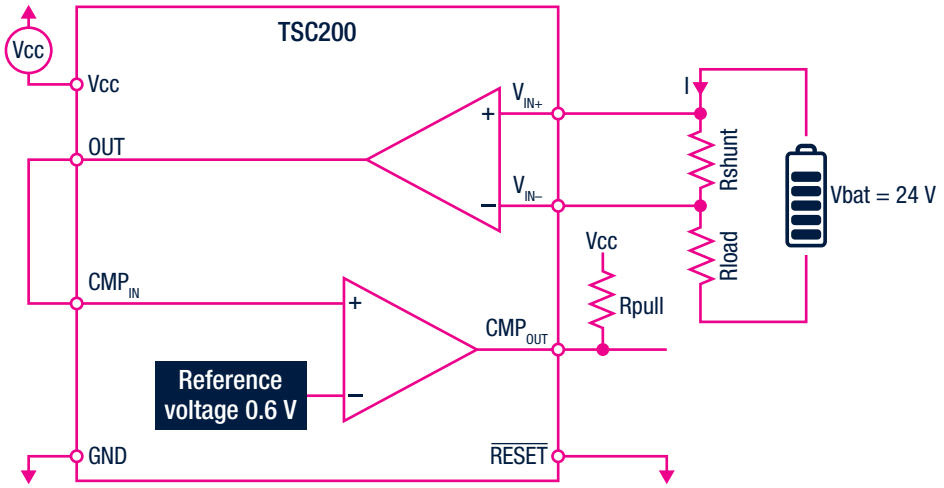


All in one

A third option is to use a dedicated device like the TSC200, which integrates both a current sensing amplifier and a comparator in the same package. This device is designed to measure current by amplifying the voltage across a shunt resistor at its input. It includes a 0.6 V bandgap reference and a comparator that can latch the output, functioning as an overcurrent protection device.

See fig 3. This solution offers the great advantage of using extremely few external components allowing a strong optimization of the PCB area and easier supply chain management. Integration of gain, reference voltage and comparator allow a better approach as well for accurate measurement, as it is less temperature dependent and has a better mismatch.

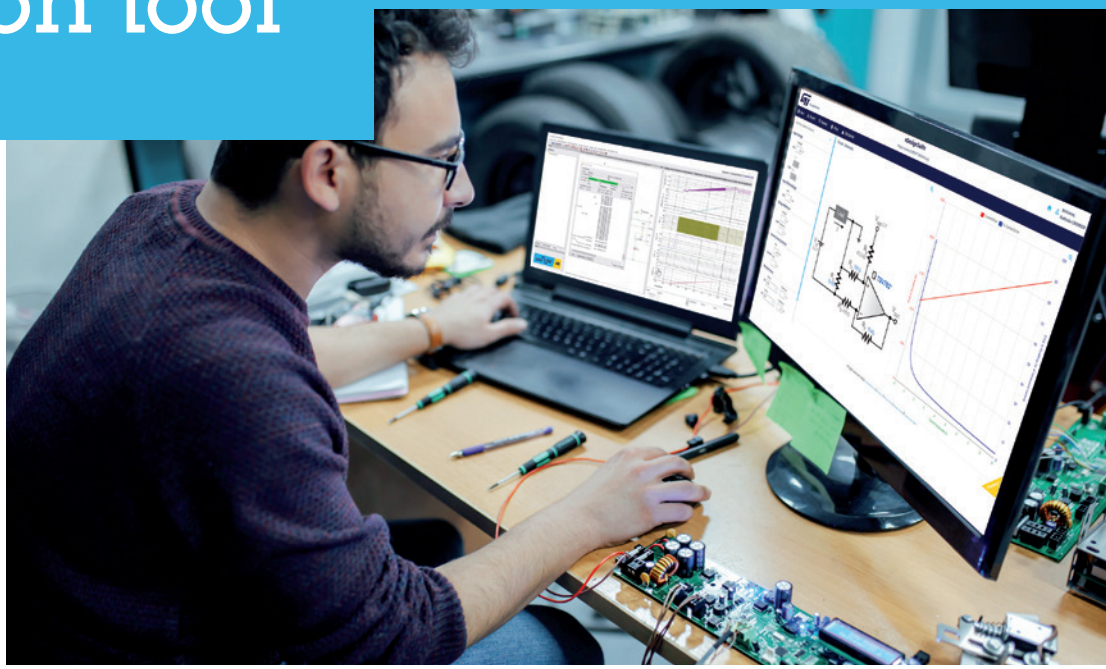
Figure 3 OCP function with dedicated device TSC200



CONCLUSION

Monitoring current is essential in many types of applications. Additionally, being able to accurately and quickly detect potential issues, such as an overcurrent event, helps improve the robustness of the application. There are many overcurrent detection solutions, each with its own advantages depending on the application constraints.

eDesignSuite and eDSim: a comprehensive design and simulation tool



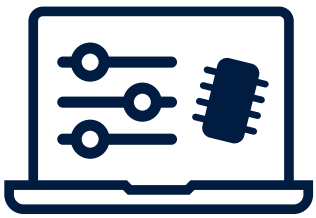
THE SMART DESIGN TOOL

ST **eDesignSuite** is a smart design and simulation tool that greatly simplifies the task of engineers working on various application types. This platform helps to select the best product for your application and speeds-up the design-in! To use the eDesignSuite, you must first register on MyST at

https://st.com/eDesignSuite

Available modules

- Power management
- Thermo-electrical simulator
- Signal conditioning
- NFC/RFID calculators



STEP 1

- Select the signal conditioning mode

STEP 2

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

STEP 3

- Adjust parameters depending on your applications

…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 application easily
- Access the datasheet
- Access the product folder
- Save and export a PSPICE model
- Export for **eDSim**

eDSim

Free, fast, and powerful electrical simulation software for analog ICs.

Crunch your electrical simulations 10-50 times faster than traditional analog SPICE simulators.

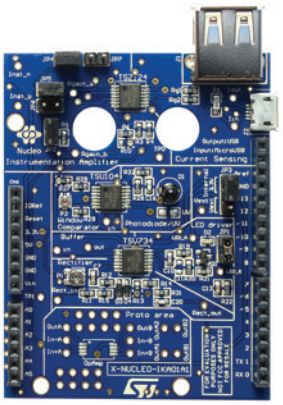
FIND OUT MORE

www.st.com

Hardware and software utilities

The STM32 Open Development Environment is a fast and affordable way to develop and prototype innovative devices and applications with state-of-the-art ST components leveraging the STM32 32-bit microcontroller family and a comprehensive set of functions for sensing, connectivity, power, audio, motor control and more. The combination of a broad range of expandable boards based on leading-edge commercial products and modular software, from driver to application level, enables fast prototyping of ideas that can be smoothly transformed into final designs.

OP AMP NUCLEO EXPANSION BOARD



Use the X-NUCLEO-IKA01A1 multifunctional op amp expansion board for STM32 Nucleo

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.

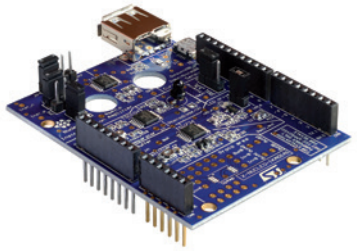
It is compatible with the X-NUCLEO-IKA01A1 expansion board plugged to a NUCLEO-F401RE, NUCLEO-F103RB, NUCLEO-L053R8, or NUCLEO-L476RG board.

FIND OUT MORE

www.st.com

ALL THAT YOU NEED

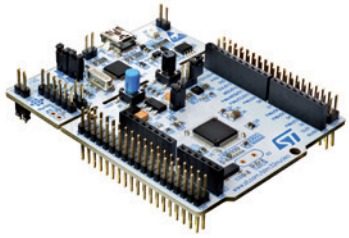
Hardware



Multifunctional expansion board

Multifunctional expansion board based on operational amplifiers

ST Op Amps X-NUCLEO-IKA01A1



STM32 Nucleo-64 development board

STM32F4 MCU

STM32 Nucleo NUCLEO-F401RE

Software (Free of charge)

Multifunctional software expansion X-CUBE-ANALOG1

STM32Cube

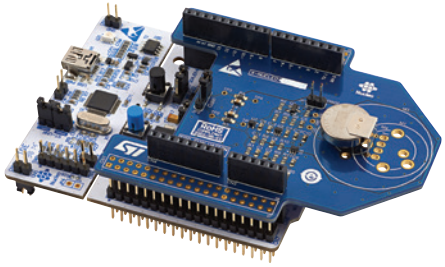
ELECTROCHEMICAL TOXIC GAS SENSOR EXPANSION BOARD

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.



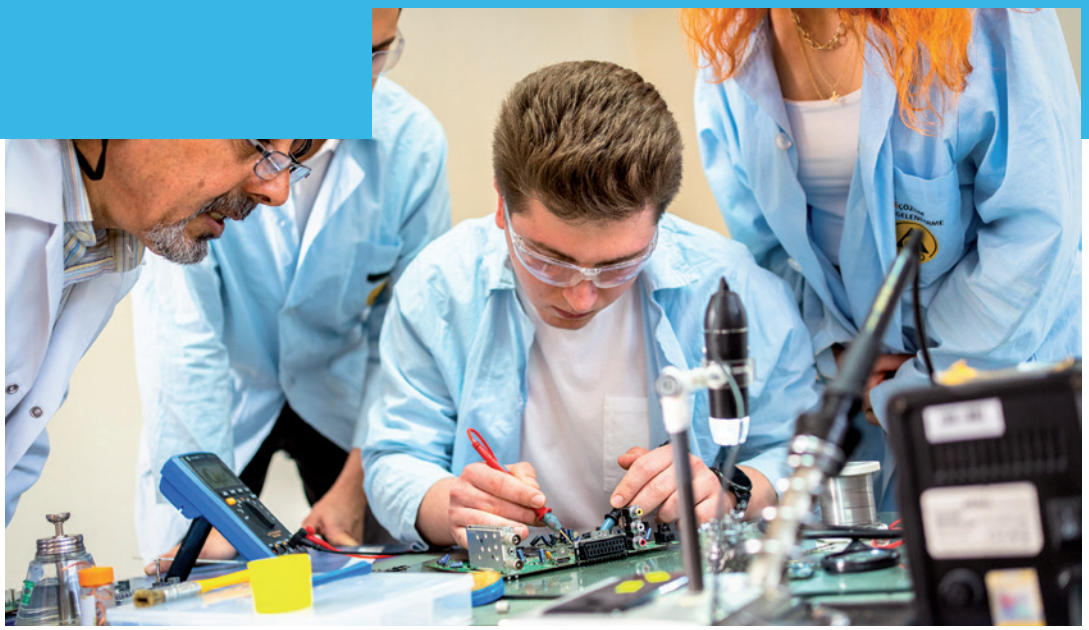
BARE EVALUATION BOARDS

Designed for use with our dual-channel op amps, this collection of bare PCB evaluation boards lets you quickly prototype new circuits and reduce design time.

Get started with our current sensing amplification stage configuration design tool and eDesignSuite smart simulator and system design engine.

Order code	Description	Reference
STEVAL-CCA057V1	Evaluation board for dual-channel op amps in a SO8 package	AN4495
STEVAL-CCA057V2	Evaluation board for dual-channel op amps in a MiniSO8 package	AN4574
STEVAL-CCA057V3	Evaluation board for dual-channel op amps in a MiniSO10 package	AN4575
STEVAL-CCA057V4	Evaluation board for dual-channel op amps in a DFN8 with exposed pad package	AN4576
STEVAL-CCA057V5	Evaluation board for dual-channel op amps in a DFN8 package	AN4577

Training kit



TRAINING KIT FOR OPERATIONAL AMPLIFIERS AND COMPARATORS

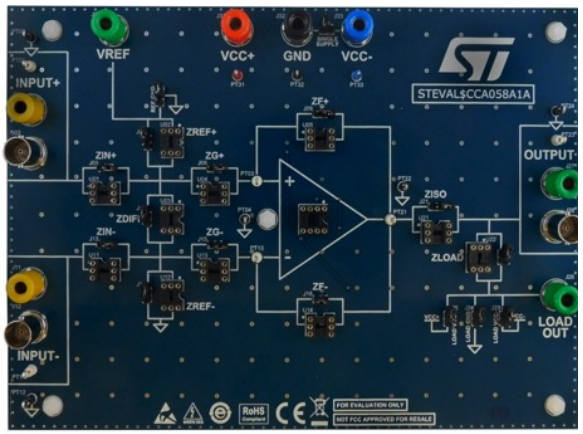
Easy-to-use setup for experimenting and learning with low-frequency op amp-based applications and common op amp-based schematics.

STEVAL-CCA058V1

The ready-to-use **STEVAL-CCA058V1** kit is designed to provide hands-on training for operational amplifiers and comparator-based analog circuits. The kit can be used in both academic and professional contexts, including for training students, junior analog engineers, distributors, and customers. Additionally, it is useful for quickly evaluating and prototyping low-frequency op-amp-based applications. The kit includes a configurable board with commonly used op-amp-based schematics and applications, as well as ST op-amps mounted on DIP adaptors. It should be used with a set of passive components (resistors and capacitors) and lab instruments (power supply, function generator, multimeter, and oscilloscope). The kit enables trainees to experiment with common op-amp-based schematics and learn how to select the most appropriate op amp for a custom application.

FEATURES

- Schematics and applications based on operational amplifiers and comparators:
  - Follower, inverter, non-inverter
  - Filters
  - Low-side current sensing
  - Photodiode transimpedance amplification
- Low cost to high-performance low-voltage operational amplifiers:
  - Rail-to-rail
  - High bandwidth
  - Low offset
  - High output current
  - Low-power

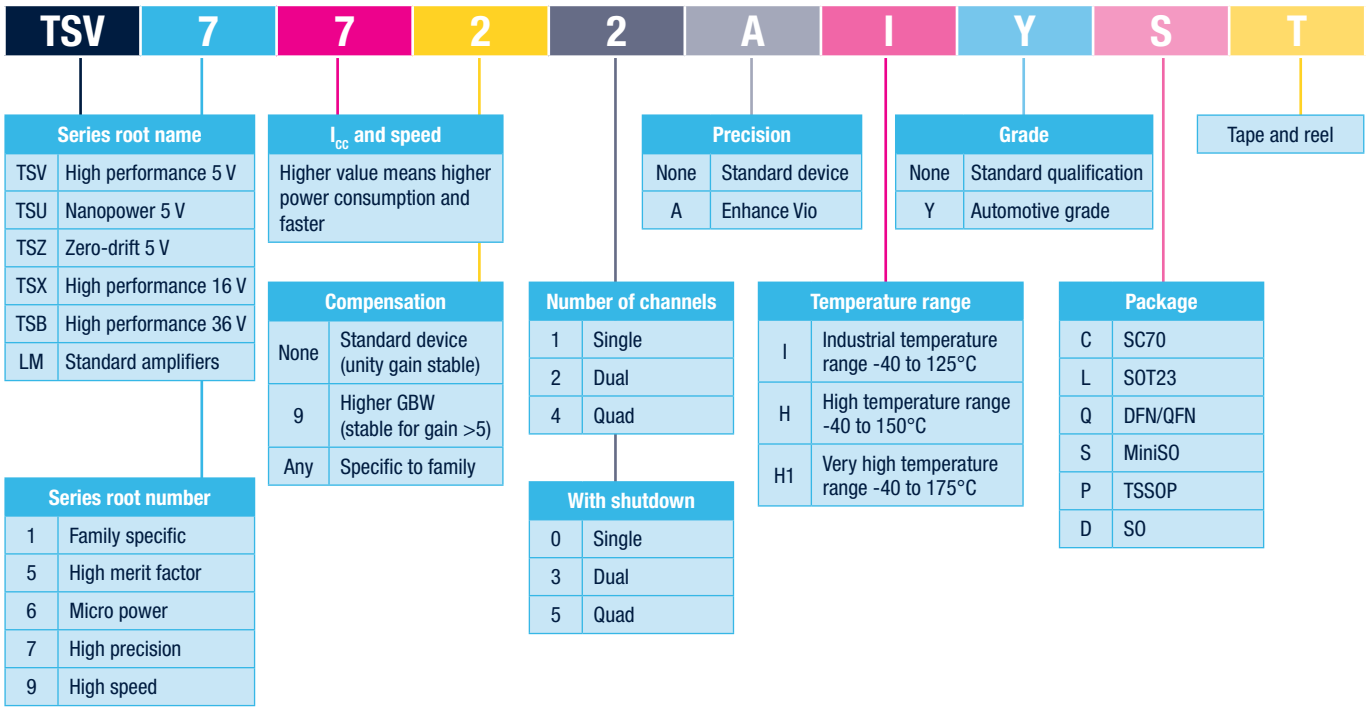


Order code	Description	Reference
STEVAL-CCA058V1	Training kit for operational amplifiers and comparators	DB4654

FIND OUT MORE

www.st.com/OpAmpsTraining

Op amps part numbering scheme



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

Number of channels	
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

Tape and reel

At STMicroelectronics we create technology that starts with You

Order code: **BR2507OPAMPPERF**

For more information on ST products and solutions, visit www.st.com