0.05μV/°C max CMOS OPERATIONAL AMPLIFIERS Zero-Drift Series

FEATURES

- **Low Offset Voltage: 5μV (max)**
- **Zero-Drift: 0.05μV/°C (max)**
- **High Gain Bandwidth Product: 2.4MHz**
- **Low Noise: 0.8uV$_{P-P}$ (0.1~10Hz)**
- **Rail-to-Rail Input/Output**
- **Quiescent Current: 365μA**
- **Single and Dual Channel**
- **Temperature: -40℃ to +125℃**
- **Low Supply Voltage: +2.7V to +5.5V**

APPLICATIONS

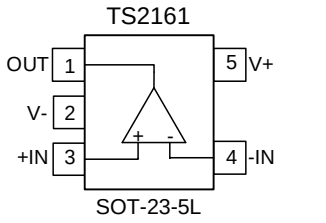
- **Medical/Industrial Instrumentation**
- **Transducer Applications**
- **Electronic Scales**
- **Battery-Powered Applications Handheld**
- **Handheld Test Equipment**
- **Precision Current Sensing**
- **Thermocouple Amplifiers**

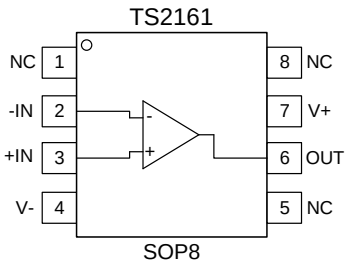
PRODUCT DESCRIPTION

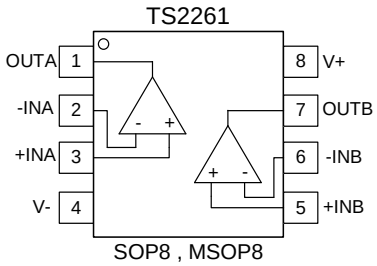
The TS2X61 series operational amplifier has extremely low offset voltage (5μV max), and near-zero drift over time and temperature. These miniature, high-precision, low quiescent current amplifiers offer high input impedance and rail-to-rail input/output swing. Supplies as low as +2.7V (±1.35V) and up to +5.5V (±2.75V) may be used.

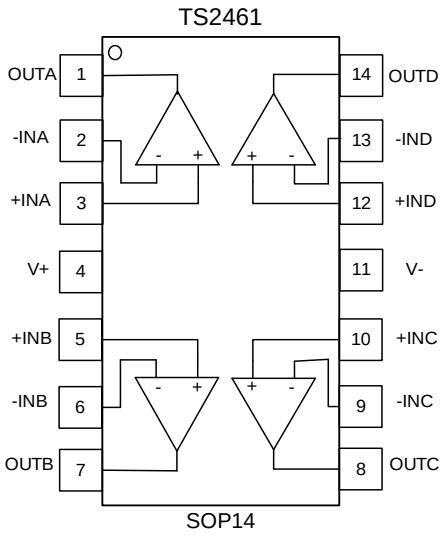
The TS2161 (single version) comes in SOT23-5. The TS2261 (dual version) comes in SOP8 and MSOP8. All versions are specified for operation from –40°C to +125°C.

PIN ASSIGNMENTS









ORDERING INFORMATION

Model	Part Number	Eco Plan	Package	AMP	Shutdown	Container, Pack Qty
TS2161	TS2161SOT235LR	RoHS	SOT-23-5L	1	NO	Reel, 3000
TS2161	TS2161SOP8R	RoHS	SOP8	1	NO	Reel, 2500
TS2261	TS2261SOP8R	RoHS	SOP8	2	NO	Reel, 2500
TS2261	TS2261MSOP8R	RoHS	MSOP8	2	NO	Reel, 3000
TS2461	TS2461SOP14R	RoHS	SOP14	4	NO	Reel, 2500

ABSOLUTE MAXIMUM RATINGS

Over operating free-air temperature range (unless otherwise noted) (1)

Parameter	Min	Max	Unit
Supply Voltage		7	V
Signal Input Terminal Voltage	(V-) - 0.5	(V+) + 0.5	V
Operating Temperature	-40	150	˚C
Junction Temperature		150	˚C
Storage Temperature Range	-65	150	˚C
Lead Temperature (Soldering, 10s)		260	˚C
ESD HBM	±3000V		
ESD MM	±300V		
ESC CDM	±1000V		

(1) Stresses beyond those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ESD CAUTION

ESD (electrostatic discharge) sensitive device

Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjects to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

ELECTRICAL CHARACTERISTICS: V_S = +2.7V to +5.5V

Boldface limits apply over the specified temperature range, **T_A = −40℃ to +125℃.**

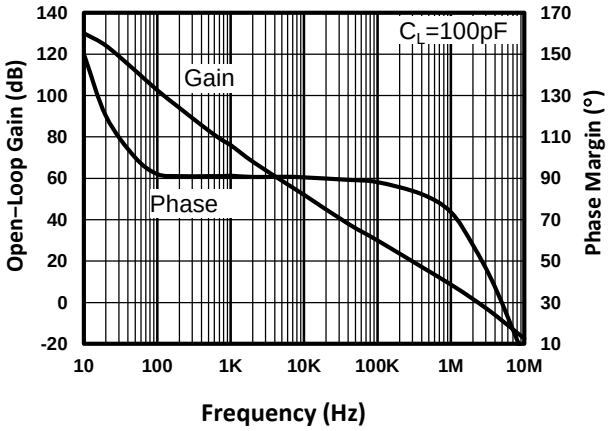
At T_A = +25℃, V_S = 5V, R_L = 10kΩconnected to V_S / 2, and V_{OUT} = V_S / 2 (unless otherwise noted)

Parameter		Operating Conditions	Min	Typ	Max	Unit
V_S	Power Supply Voltage		2.7		5.5	V
I_S	Supply Current (Per Amplifer)	I_{OUT} = 0		365	550	μA
PSRR	Power Supply Rejection Ratio	V_S = 2.7V to 5.5V, V_{CM} = 0V		0.2		μV/V
		T_A = −40℃ to +125℃		**1**	**2**	**μV/V**
Input Characteristics						
V_{OS}	Input Offset Voltage	V_S = 5V		1	5	μV
dV_{OS}/dT	**Average Drift**			**0.02**	**0.05**	**μV/℃**
I_B	Input Bias Current			50		pA
I_{OS}	Input Offset Current			50		pA
$V_{IN+/-}$	Input Common Mode Voltage		(V-) - 0.1		(V+) + 0.1	V
CMRR	Common Mode Rejection Ratio	(V−) − 0.1V < V_{CM} < (V+) + 0.1V		130		dB
		T_A = −40℃ to +125℃	**110**			**dB**
AOL	Open-Loop Gain	Vs = 5V, R_L = 10kΩ (V-) + 100mV < Vout < (V+) – 100mV		130		dB
		T_A = −40℃ to +125℃	**110**			**dB**
		Vs = 5V, R_L = 100kΩ (V-) + 20mV < Vout < (V+) - 50mV		130		dB
		T_A = −40℃ to +125℃	**110**			**dB**
Output Characteristics						
V_{OUT}	**Output Voltage Swing from Rail**	**R_L = 100kΩ T_A = −40℃ to +125℃**			**50**	**mV**
		R_L = 10kΩ T_A = −40℃ to +125℃			**100**	**mV**
I_{SC}	Output Short Circuit Current	Vs = 5V		45		mA
Dynamic Performance						
GBW	Gain Bandwidth Product	C_L =100pF		2.4		MHz
SR	Slew Rate	G = +1, C_L = 100pF		1.7		V/μs
Noise Performance						
V_{noise}	Input Voltage Noise	f = 0.1Hz to 10Hz		0.8		μVpp
e_n	Input Voltage Noise Density	f = 1kHz		32		$nV/\sqrt{Hz}$
Thermal Resistance						
	SOT-23-5L			200		
θ_{JA}	SOP8			150		ºC/W
	MSOP8			200		

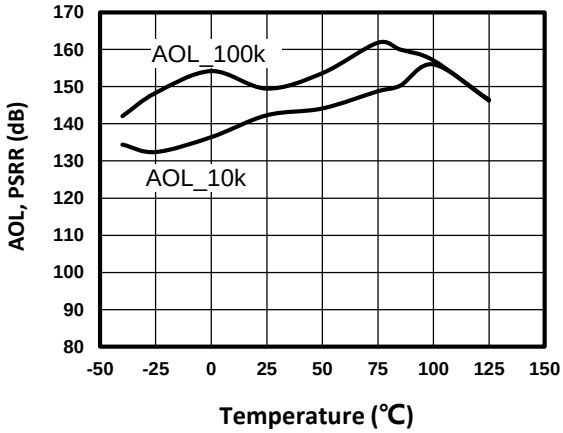
TYPICAL CHARACTERISTICS

At T_A = +25°C, V_S = 5V, R_L = 10kΩ connected to V_S / 2, and V_{OUT} = V_S / 2 (unless otherwise noted)

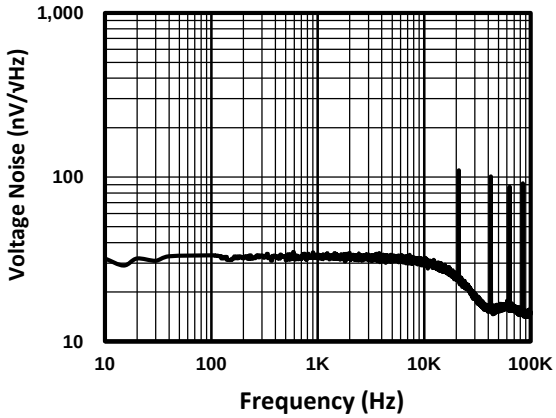
Open−Loop Gain and Phase vs Frequency



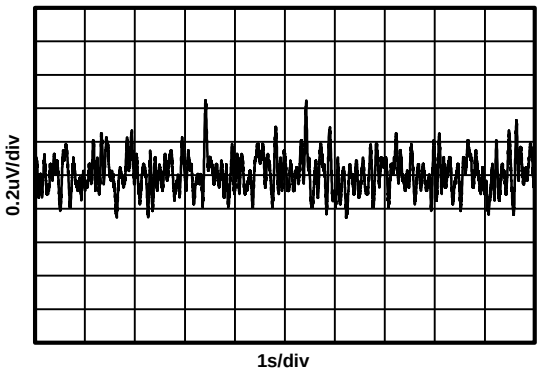
Open−Loop Gain vs Temperature



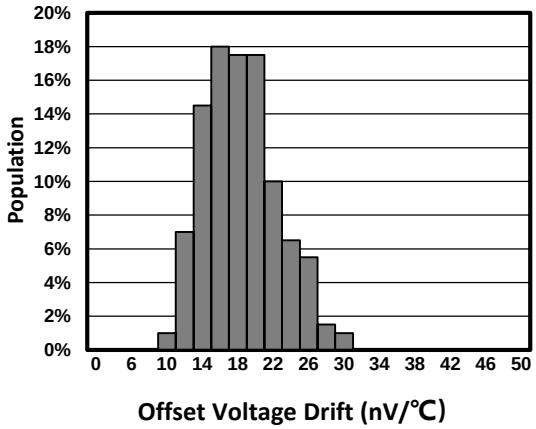
Input Voltage Noise
Spectral Density vs Frequency



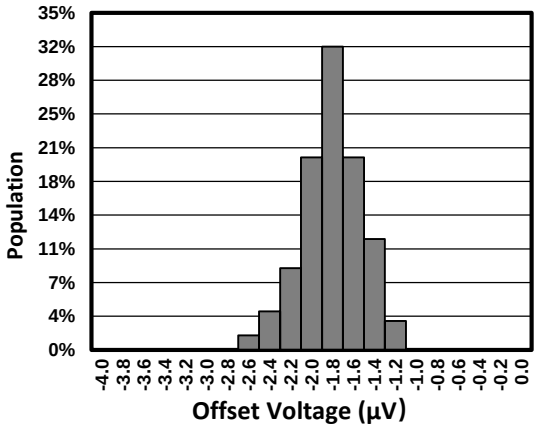
0.1Hz to 10Hz Noise



Offset Voltage Drift Magnitude
Production Distribution



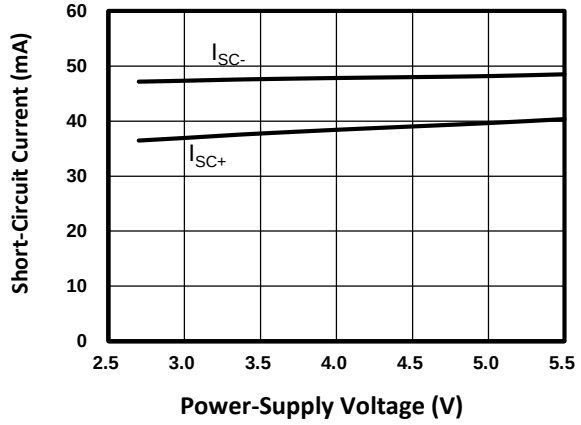
Offset Voltage
Production Distribution



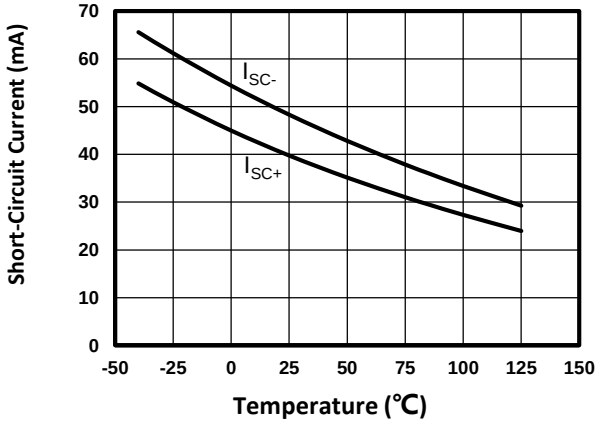
TYPICAL CHARACTERISTICS (CONTINUE)

At T_A = +25°C, V_S = 5V, R_L = 10kΩ connected to V_S / 2, and V_{OUT} = V_S / 2 (unless otherwise noted)

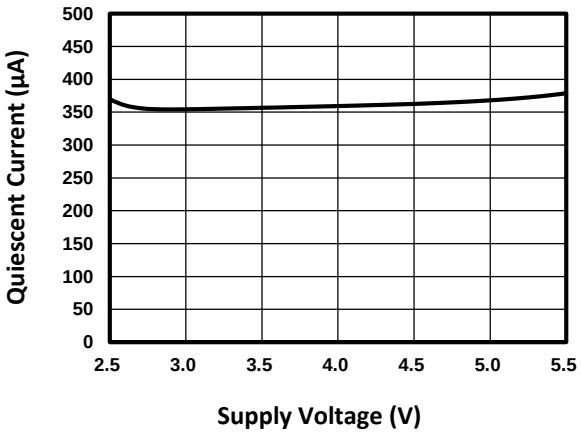
Continuous Short-Circuit Current vs Power-Supply Voltage



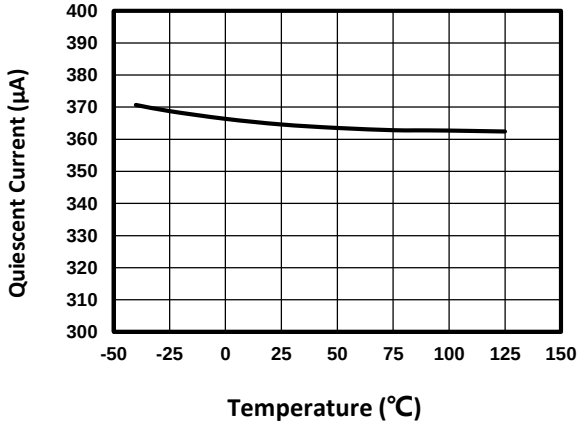
Short-Circuit Current vs Temperature



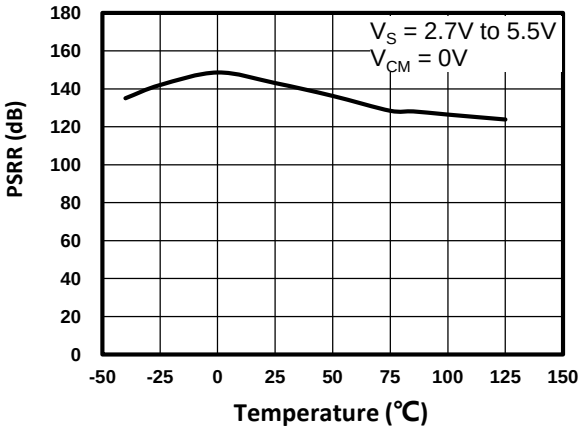
Quiescent Current vs Supply Voltage



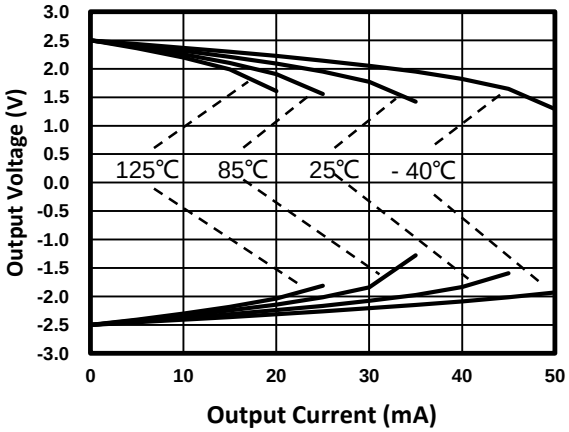
Quiescent Current vs Temperature



Power–Supply Rejection Ratio vs Temperature



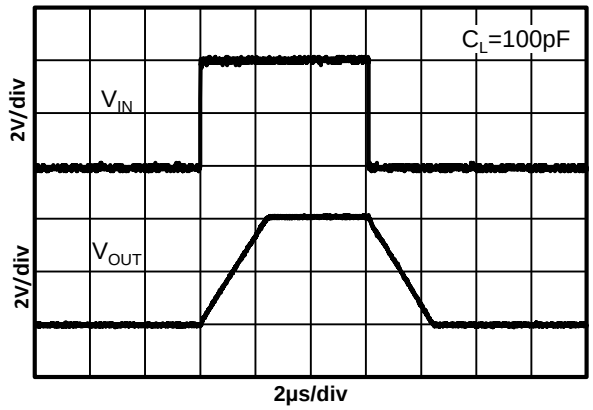
Output Voltage Swing vs Output Current



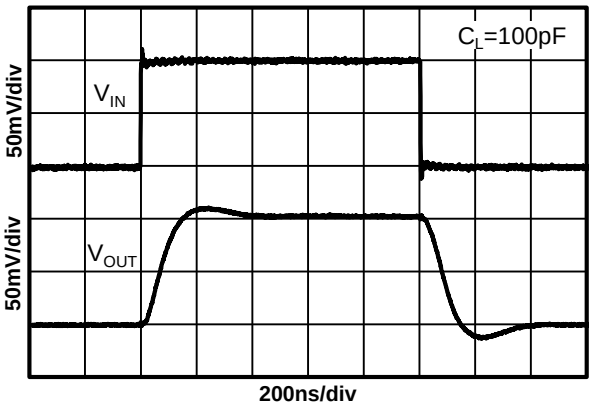
TYPICAL CHARACTERISTICS (CONTINUE)

At T_A = +25°C, V_S = 5V, R_L = 10kΩ connected to V_S / 2, and V_{OUT} = V_S / 2 (unless otherwise noted)

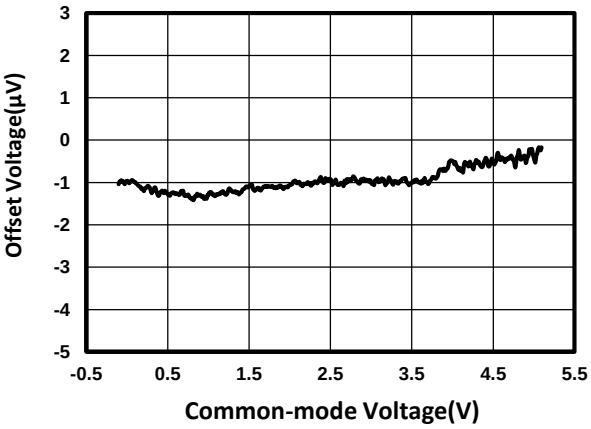
Large-Signal Step Response



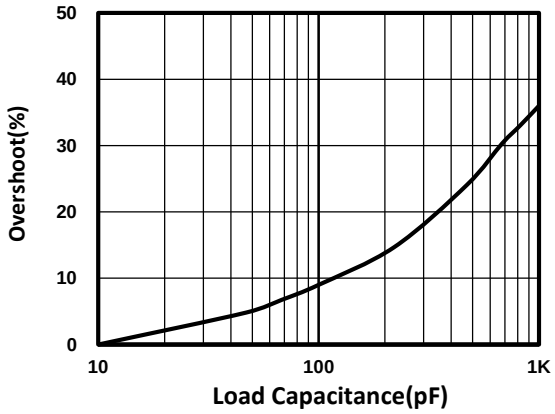
Small-Signal Step Response



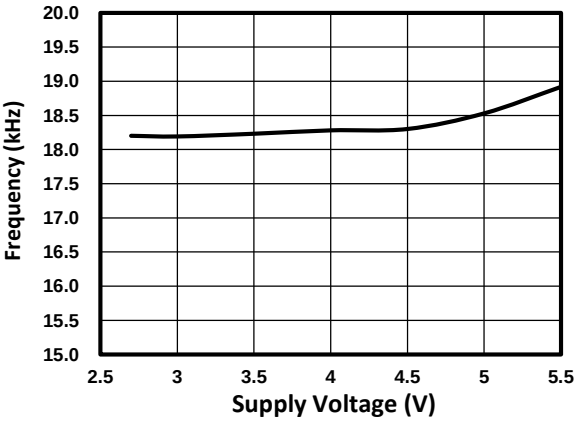
Common-Mode Voltage vs Offset Voltage



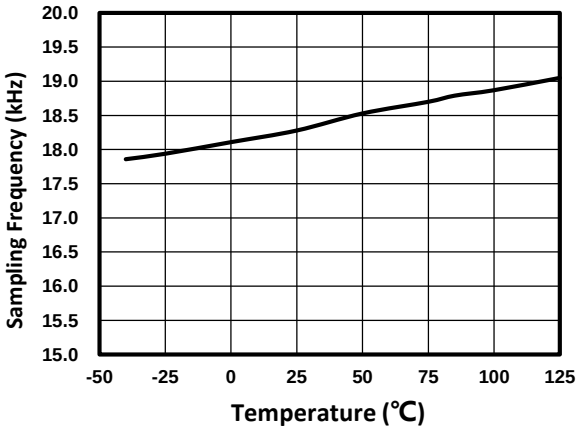
Small-Signal Overshoot vs Load Capacitance



Sampling Frequency vs Supply Voltage



Sampling Frequency vs Temperature



APPLICATION NOTES

The TS2161 and TS2261 use auto-zeroing techniques to provide low offset voltage and very low drift over time and temperature. They provide Rail-to-rail input and output.

Placing a 0.1 μF capacitor tightly on the power pin is recommended.

By optimizing the layout and mechanical conditions of the circuit, the effect of the thermocouple junction formed by the connection is avoided: the temperature gradient (Seebeck) of different conductors generating thermoelectric effects. These heat generated potentials can cancel the two input terminals by ensuring that they are equal in time.

To reduce the likelihood of junctions being at different temperatures, follow these guidelines:

- Use low thermoelectric-coefficient connections.
- Thermally isolate components from power supplies or other heat-sources.
- Shield op amp and input circuitry from air currents.

POWER SUPPLY

The TS2161 and TS2261 series op amps operate over a power-supply range of +2.7V to +5.5V (±1.35V to ±2.75V). Supply voltages higher than 7V (absolute maximum) can permanently damage the amplifier.

INPUT VOLTAGE

The input common-mode range extends from (V–) – 0.1V to (V+) +0.1V. For normal operation, the inputs must be limited to this range. The common-mode rejection ratio is only valid within the valid input common-mode range.

Normally, input bias current is approximately 50pA; however, input voltages exceeding the power supplies can cause excessive current to flow in or out of the input pins. If the input pin current is limited by resistance, it can withstand higher transient voltage.

LAYOUT SUGGESTIONS

The following layout practices are always recommended:

- Keep traces short.
- When possible, use a PCB ground plane with surface-mount components placed as close to the device pins as possible.
- Place a 0.1μF capacitor closely across the supply pins.
- Pay attention to thermoelectric EMF.

TYPICAL APPLICATION

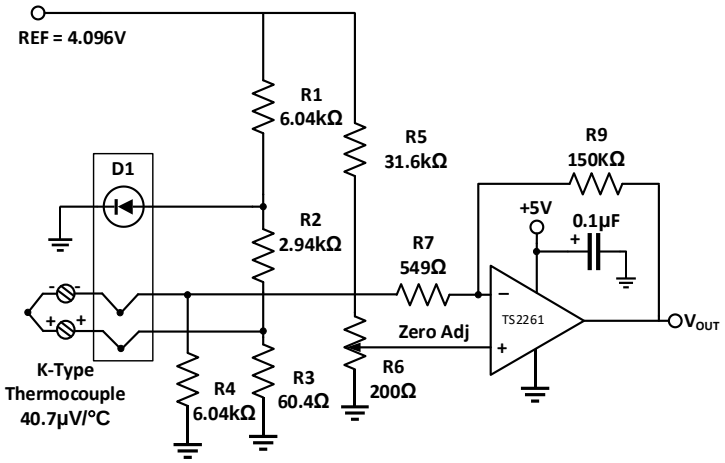
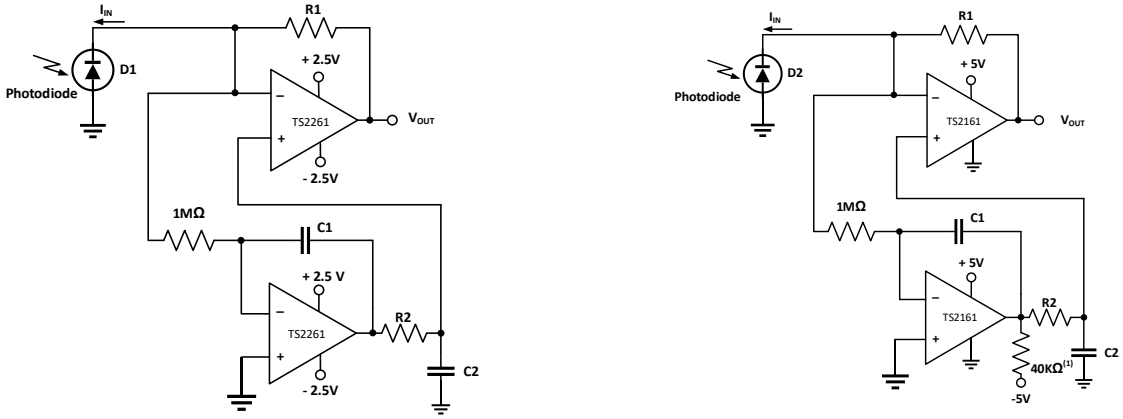
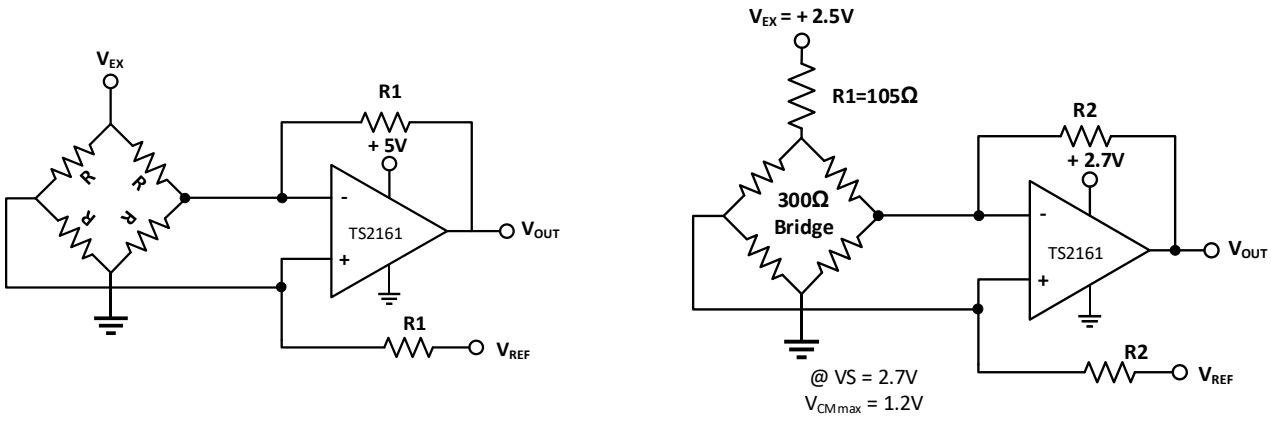


Figure 2. Temperature Measurement Circuit



a. Split Supply b. Single Supply

Figure 3. Auto-Zeroed Transimpedance Amplifier



a. 5V Supply Bridge Amplifier b. 2.7V Supply Bridge Amplifier

Figure 4. Single Op Amp Bridge Amplifier Circuits

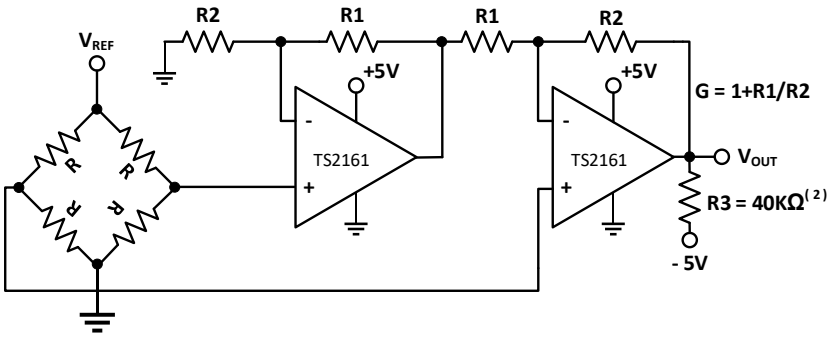


Figure 5. Dual Op Amp IA Bridge Amplifier

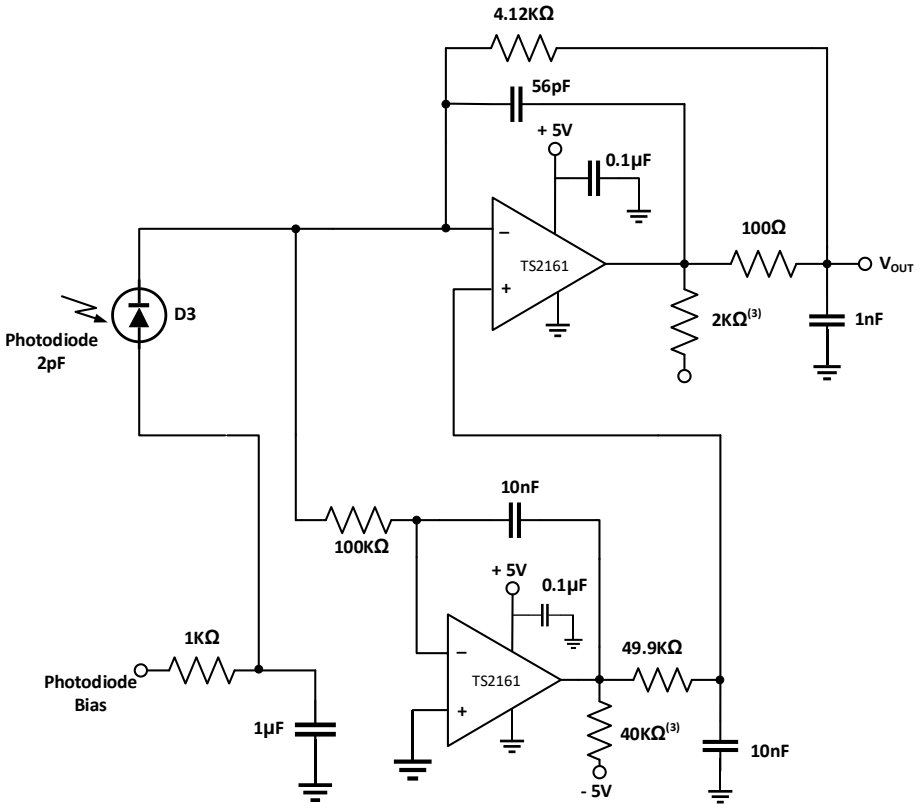
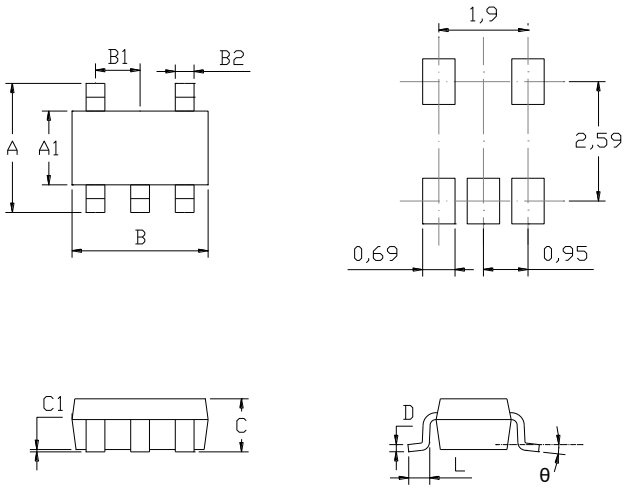


Figure 6. High Dynamic Range Transimpedance Amplifier

NOTE: (1) Optional pull-down resistor to allow below ground output swing.
(2) Optional pull-down resistor to allow accurate swing to 0V.
(3) Pull-down resistors to allow accurate swing to 0V.

MECHANICAL DIMENSIONS

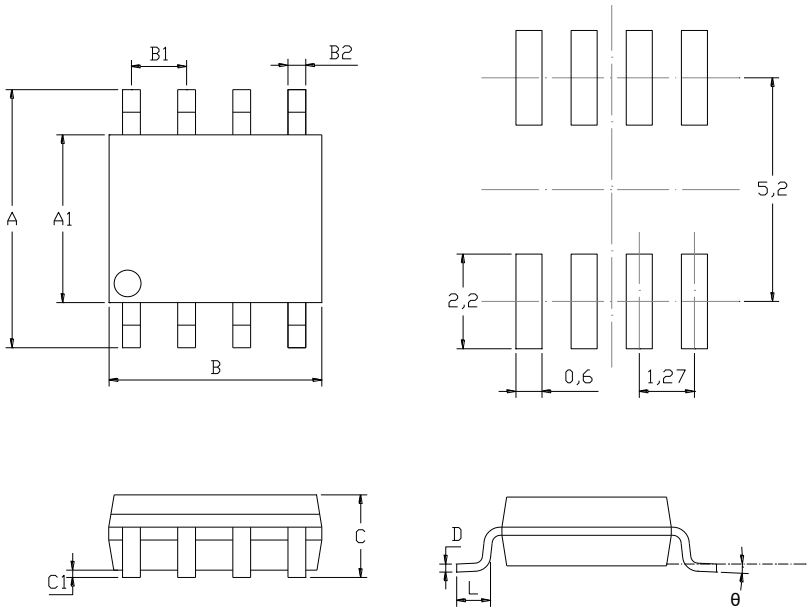
SOT-23-5L PACKAGE MECHANICAL DRAWING



SOT-23-5L PACKAGE MECHANICAL DATA

symbol	dimensions			
	millimeters		inches	
	min	max	min	max
A	2.650	2.950	0.104	0.116
A1	1.500	1.700	0.059	0.067
B	2.820	3.020	0.111	0.119
B1	0.950		0.037	
B2	0.300	0.500	0.012	0.020
C		1.250		0.049
C1	0	0.100	0	0.004
L	0.300	0.600	0.012	0.024
D	0.100	0.200	0.004	0.008
θ	0°	8°	0°	8°

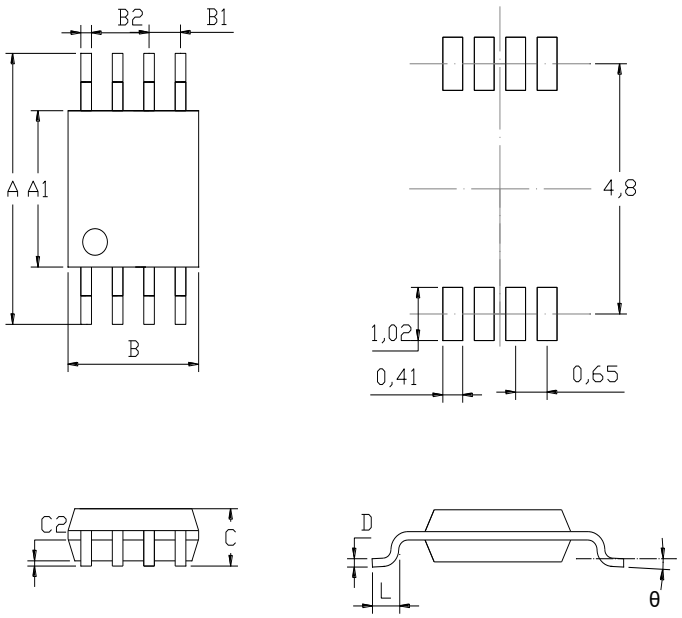
SOP8 PACKAGE MECHANICAL DRAWING



SOP8 PACKAGE MECHANICAL DATA

symbol	dimensions			
	millimeters		inches	
	min	max	min	max
A	5.800	6.200	0.228	0.244
A1	3.800	4.000	0.150	0.157
B	4.700	5.100	0.185	0.201
B1	1.270		0.050	
B2	0.330	0.510	0.013	0.020
C		1.750		0.069
C1	0.100	0.250	0.004	0.010
L	0.400	1.270	0.016	0.050
D	0.170	0.250	0.006	0.010
θ	0°	8°	0°	8°

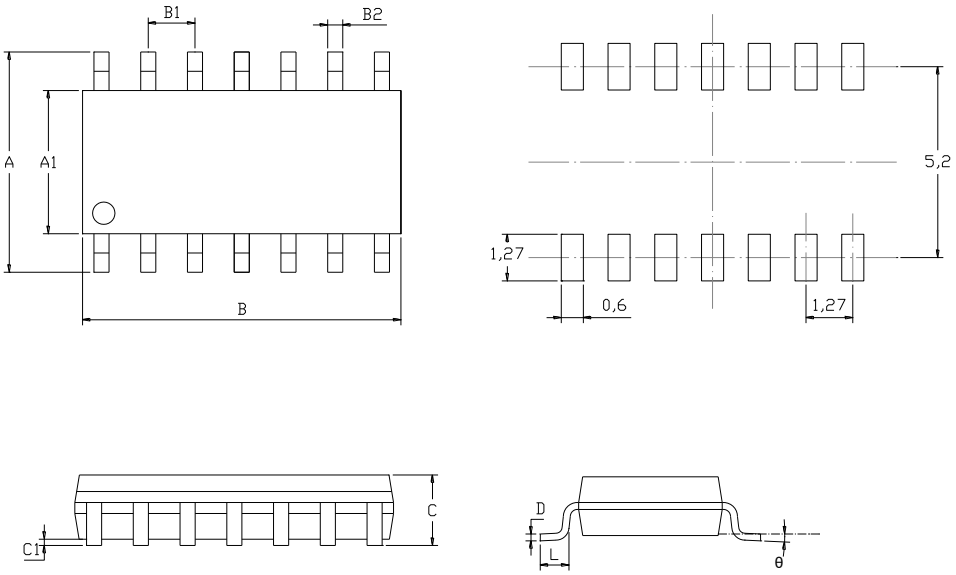
MSOP8 PACKAGE MECHANICAL DRAWING



MSOP8 PACKAGE MECHANICAL SPECIFICATIONS

symbol	dimensions			
	millimeters		inches	
	min	max	min	max
A	4.750	5.050	0.187	0.199
A1	2.900	3.100	0.114	0.122
B	2.900	3.100	0.114	0.122
B1	0.650		0.026	
B2	0.250	0.380	0.010	0.015
C	0.820	1.100	0.032	0.043
C2	0.020	0.150	0.001	0.006
L	0.400	0.800	0.016	0.031
D	0.090	0.230	0.004	0.009
θ	0º	6º	0º	6º

SOP14 PACKAGE MECHANICAL DRAWING

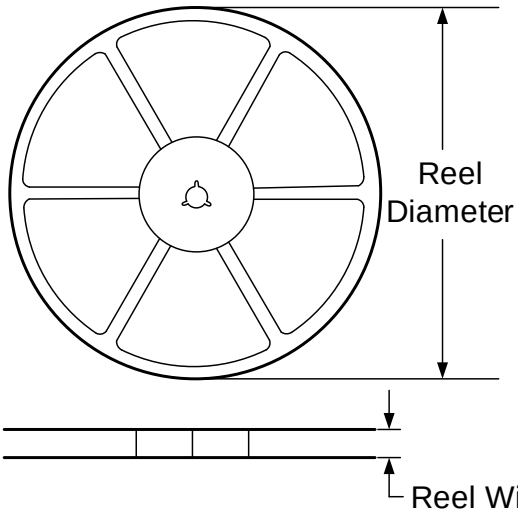


SOP14 PACKAGE MECHANICAL DATA

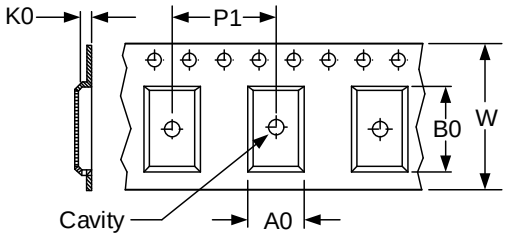
symbol	dimensions			
	millimeters		inches	
	min	max	min	max
A	5.80	6.20	0.228	0.244
A1	3.80	4.00	0.150	0.157
B	8.45	8.85	0.333	0.348
B1	1.27		0.050	
B2	0.31	0.51	0.012	0.020
C		1.75		0.069
C1	0.10	0.25	0.004	0.010
L	0.40	1.27	0.016	0.050
D	0.10	0.25	0.004	0. 010
θ	0º	8º	0º	8º

TAPE AND REEL INFORMATION

REEL DIMENSIONS

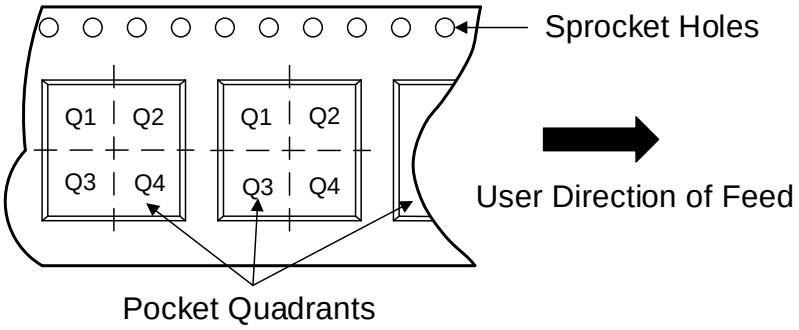


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component width thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



Device	Package Type	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
TS2161SOT235LR	SOT-23-5L	5	3000	180.0	9.0	3.2	3.3	1.4	4.0	8.0	Q3
TS2161SOP8R	SOP8	8	2500	330.0	12.4	6.4	5.4	2.1	8.0	12.0	Q1
TS2261SOP8R	SOP8	8	2500	330.0	12.4	6.4	5.4	2.1	8.0	12.0	Q1
TS2261MSOP8R	MSOP8	8	3000	330.0	12.4	5.2	3.3	1.5	8.0	12.0	Q1
TS2461SOP14R	SOP14	14	2500	330.0	12.4	6.5	9.0	2.1	8.0	16.0	Q1

REVISION HISTORY

NOTE: Page numbers for previous revisions may be different from that of the current version.

2022/3/22 — REV KY1.0.0 to REV KY1.1.0

Updated MOSP10 to SOP8……..……..…….. …….. …….. ..1,2,3,12,13
Updated TS2261E to TS2261……..……..…….. …….. …….. 1,2,13
Added TYPICAL CHARACTERISTICS……..……..…….. …….. …….. …….. … 6

2022/6/13 — REV KY1.1.0 to REV KY1.2.0

Added MSOP8……..……..…….. …….. …….. ... ……1,2,3,13,14

2022/7/13 — REV KY1.2.0 to REV KY1.3.0

Added SOP14……..……..…….. …….. …….. ... …… ……1,2,3,13,14

2022/10/21 — REV KY1.3.0 to REV KY1.4.0

Increase common mode voltage range……..……..…….. …….. …….. ... …… ……3

2022/10/21 — REV KY1.4.0 to REV KY1.5.0A

Update CMRR indicators……..……..…….. …….. …….. ... …… ……3,6

2023/05/31 — REV KY1.5.0 to REV KY1.5.1A

Added TS2161 SOP8…….. ..……..…….. …….. …….. ... …… ……1,2,14

CONTACT INFORMATION

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