Zero-Drift RRIO CMOS Operational Amplifier

AT8557

ORDERING GUIDE

Online Stores		Commission Fee	Unit Price (June 2024)	Buy Now
AS	shop.analogtechnologies **Our own online store**	Zero sale commission	$0.70/100PCs	*
SZ	SMTZone **Our own online store**	Zero sale commission	$0.70/100PCs	*
K	Digikey	≈32% sale commission	$0.93/100PCs	*



Figure 1. Physical Photos of AT8557

Table 1. AT8557 vs. AD8557

Parameter		AT8557	AD8557
Slew Rate		2.5V/μs	-
Bandwidth		4.3MHz	2MHz
Price	100~499pcs	$0.7	$4.51
	>1000pcs	$0.56	$3.75

FEATURES

- Upgraded Drop-in Replacement for AD8557
- Low Offset Voltage: 20μV (typ) 50μV (max)
- Input Offset Drift: 0.03μV/°C (max)
- High Gain Bandwidth Product: 4.3MHz
- Rail-to-Rail Input and Output
- High Gain, CMRR & PSRR: ≥120dB
- High Slew Rate: 2.5V/μs
- Low Noise: 0.93μV$_{P-P}$ (0.01~10Hz)
- Low Power Consumption: 650μA/op amp
- Overload Recovery Time: 1μs
- Low Supply Voltage: +2.7V to +5.5V
- No External Capacitors Required
- Extended Temperature: −40°C to +125°C

APPLICATIONS

- Temperature & Pressure Sensors Amplifier
- Weight Scale & Strain Gage Amplifiers
- Medical/Industrial Instrumentation
- Handheld Test Equipment
- Precision Current Sensing
- Thermocouple Amplifiers

DESCRIPTION

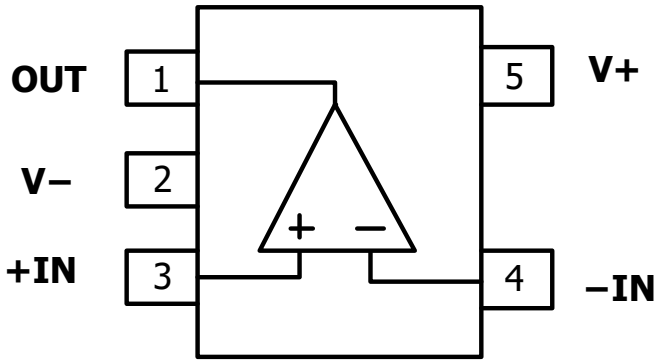
This AT8557 general-purpose CMOS operational amplifiers that provides ultralow noise, offset and power. The AT8557 use auto-zero techniques to simultaneously provide very low offset voltage (50μV max) and near-zero drift over time and temperature.

This miniature, high-precision operational amplifiers offset high input impedance and rail-to-rail input and rail-to-rail output swing. With high gain-bandwidth product of 4.3MHz and slew rate of 2.5V/μs.

This op amp operates as low as +2.7V (±1.35) and up to +5.5V (±2.75V). The AT8557 is specified for the extended industrial and automotive temperature range (−40°C to 125°C).

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PIN CONFIGURATIONS



SOT23-5

PIN DESCRIPTION

Table 2: Pin Function Table for SOT23-5

AT8557 SOT23-5	Symbol	Description
1	OUT	Analog Output
2	V–	Negative Power Supply
3	+IN	Noninverting Input
4	–IN	Inverting Input
5	V+	Positive Power Supply

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ABSOLUTE MAXIMUM RATINGS

Table 4.

Parameter	Rating
Supply Voltage, V+ to V−	7.0V
Input Terminals, Voltage (2)	−0.5 to (V+) + 0.5V
Input Terminals, Current (2)	±10mA
Storage Temperature	−65°C to +150°C
Operating Temperature	−40°C to +125°C
Junction Temperature	150°C
Package Thermal Resistance @ T_A = +25°C	
SOT23-5	200°C/W
MSOP-8, SOIC-8	150°C
Lead Temperature (Soldering, 10s)	260°C
ESD Susceptibility	
HBM	5000V
MM	400V

(1) Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under Recommended Operating Conditions is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

(2) Input terminals are diode-clamped to the power-supply rails. Input signals that can swing more than 0.5V beyond the supply rails should be current-limited to 10mA or less.

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 subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

THERMAL CHARACTERISTICS

Table 5. Thermal Resistance

Package Type	8-Lead MSOP	8-Lead SOIC	5-Lead SOT23	Unit
$R_{\theta JA}$ Junction-to-ambient thermal resistance	180.3	140.1	220.8	°C/W
$R_{\theta JC}$ (top) Junction-to-case (top) thermal resistance	48.1	89.8	97.5	°C/W
$R_{\theta JB}$ Junction-to-board thermal resistance	100.9	80.6	61.7	°C/W
ψ_{JT} Junction-to-top characterization parameter	2.4	28.7	7.6	°C/W
ψ_{JB} Junction-to-board characterization parameter	99.3	80.1	61.1	°C/W

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ELECTRICAL CHARACTERISTICS

Limits apply over the specified temperature range: T_A = −40°C to +125°C.

(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.)

Table 6.

Parameter	Symbol	Test Conditions	Min.	Typ.	Max.	Unit
INPUT CHARACTERISTICS						
Offset Voltage	V_{OS}	V_{CM} = V_S/2 T_A = −40°C to +125°C		20	50	μV
Input Bias Current	I_B	V_{CM} = V_S/2 T_A = −40°C to +125°C		50		pA
Input Offset Current	I_{OS}	T_A = −40°C to +125°C		10		pA
Input Voltage Range	V_{IN}		2.7		5.5	V
Common-Mode Voltage Range	V_{CM}		(V−) − 0.2		(V+) + 0.2	V
Common-Mode Rejection Ratio	CMRR	(V−) − 0.2V < V_{CM} < (V+) + 0.2V T_A = −40°C to +125°C	105	120		dB
Offset Voltage Drift	$\Delta V_{OS}/\Delta T$	T_A = −40°C to +125°C		0.003	0.2	μV/°C
Channel Separation, dc				0.13		μV/V
Open-Loop Gain	A_{OL}	RL=10kΩ, V_O=0.3V to 4.7V T_A = −40°C to +125°C		105	120	dB
INPUT CAPACITANCE						
Differential				1		pF
Common-Mode				5		pF
OUTPUT CHARACTERISTICS						
Output Voltage High	V_{OH}	R_L = 100kΩ to GND T_A = −40°C to +125°C	4.99	4.998		V
		R_L = 10kΩ to GND T_A = −40°C to +125°C	4.95	4.98		V
Output Voltage Low	V_{OL}	R_L = 100kΩ to V+ T_A = −40°C to +125°C		1	10	mV
		R_L = 10kΩ to V+ T_A = −40°C to +125°C		10	30	mV
Output Short-Circuit Limit Current	I_{SC}	T_A = −40°C to +125°C		48		mA

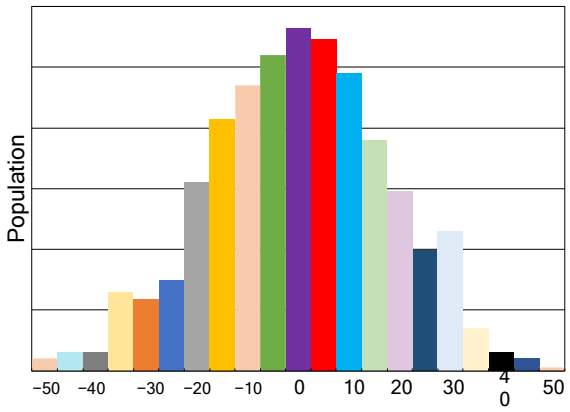
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Parameter	Symbol	Test Conditions	Min.	Typ.	Max.	Unit
POWER SUPPLY						
Power Supply Rejection Ratio	PSRR	V_S = +2.7V to +5.5V, V_{CM} = 0 T_A = −40°C to +125°C	105	120		dB
Quiescent Current/Amplifier	I_Q	V_O = 0 T_A = −40°C to +125°C		650	900	μA
Supply Voltage Range	V_{IN}		2.7		5.5	V
DYNAMIC PERFORMANCE						
Slew Rate	SR	G=+1		2.5		V/μs
Gain Bandwidth Product	GBP			4.3		MHz
Overload Recovery Time				1		μs
NOISE PERFORMANCE						
Voltage Noise	e_n p-p	0.01Hz to 10Hz		0.93		μV p-p
	e_n p-p	0.01Hz to 1Hz		0.32		μV p-p
Voltage Noise Density	e_n	f = 1kHz		45		nV/√Hz
Current Noise Density	i_n	f = 10Hz		2.3		fA/√Hz

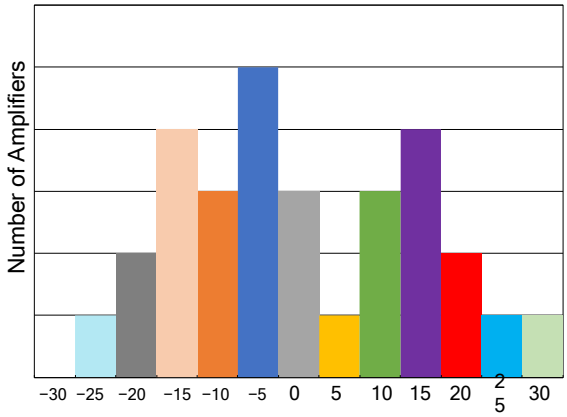
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TYPICAL CHARACTERISTICS

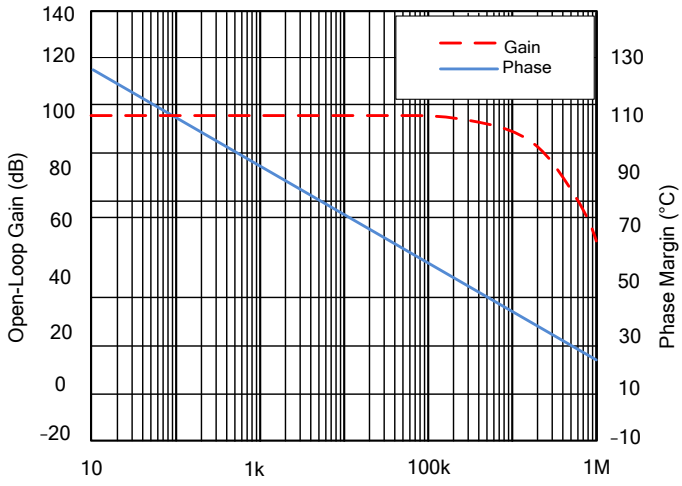
At T_A = +25°C, Vs = 5V, R_{LOAD} = 10kΩ connected to $V_S/2$, V_{OUT} = $V_S/2$, unless otherwise noted.



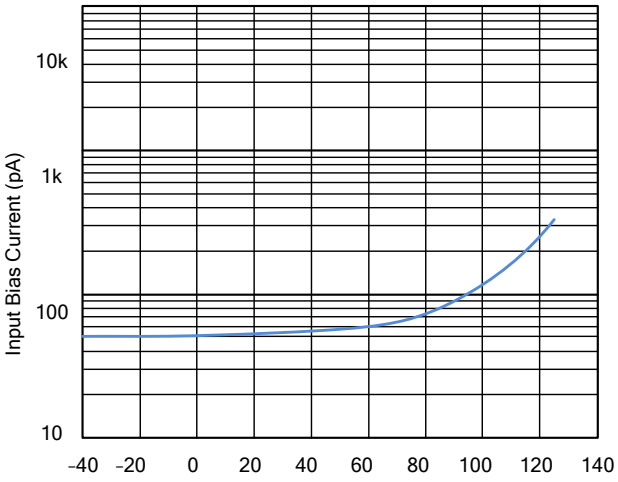
Offset Voltage Production Distribution



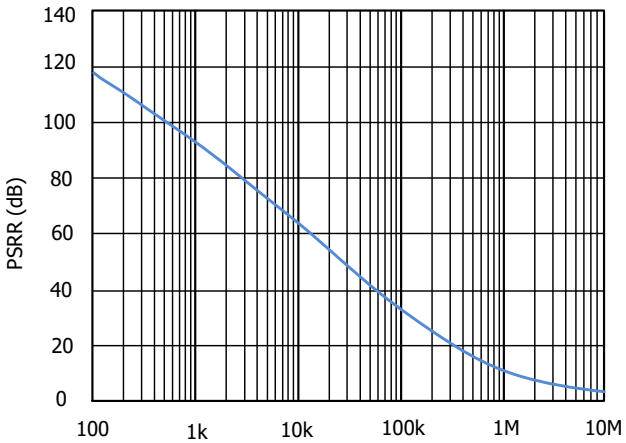
Offset Voltage Drift Production Distribution



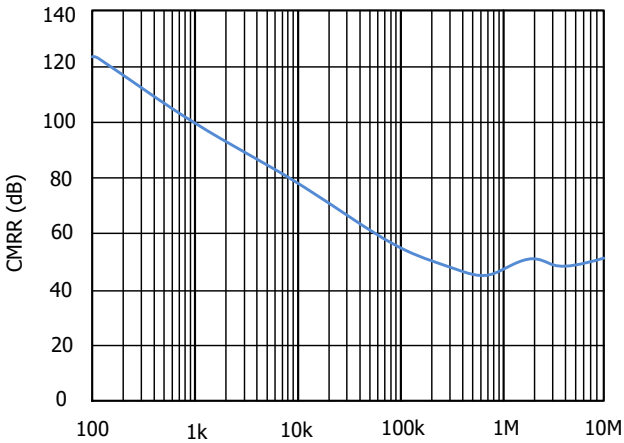
Open-Loop Gain and Phase vs. Frequency



Input Bias Current vs. Temperature

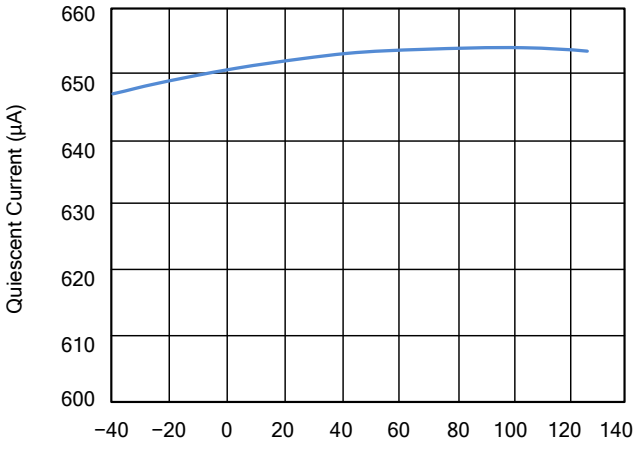


Power-Supply Rejection Ratio vs. Frequency

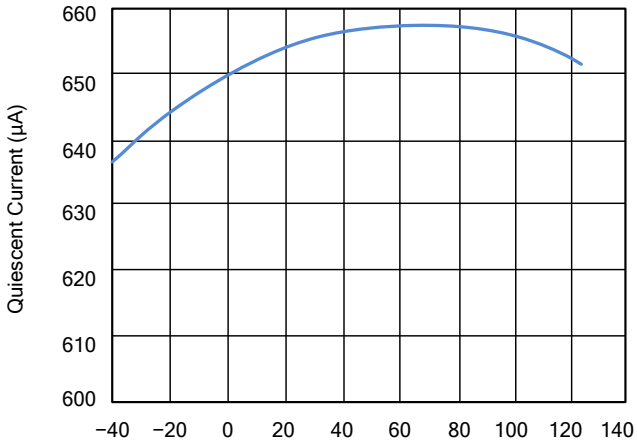


Input Bias Current vs. Temperature

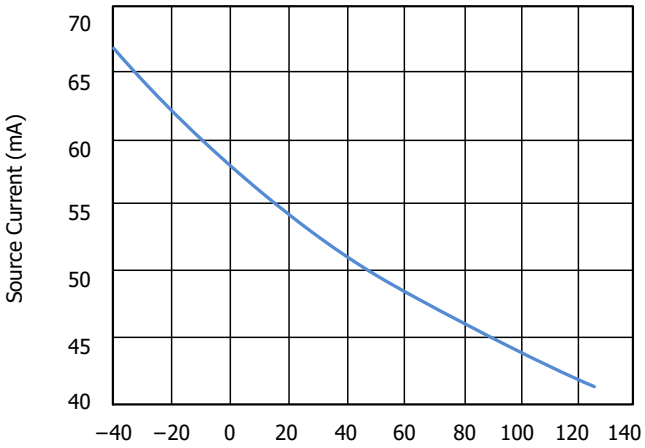
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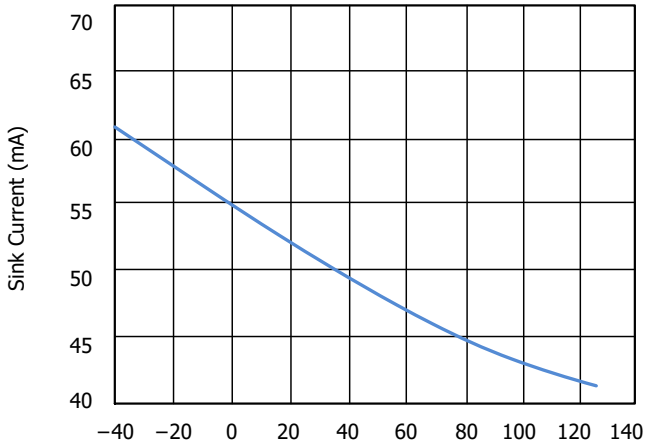
Quiescent Current vs. Temperature



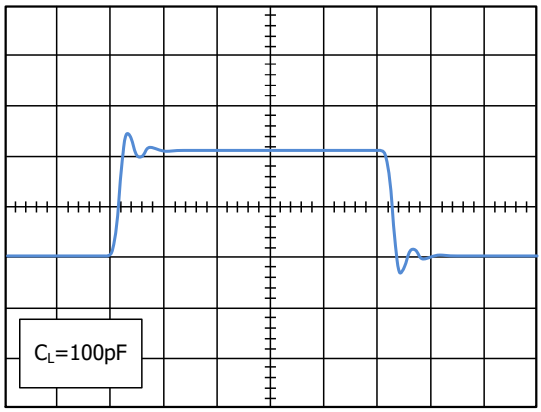
Quiescent Current vs. Temperature



Source Current vs. Temperature

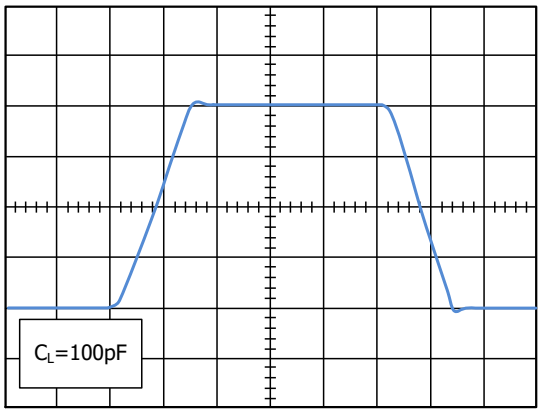


Sink Current vs. Temperature



CH1: 50mV/Div M: 200ns/Div

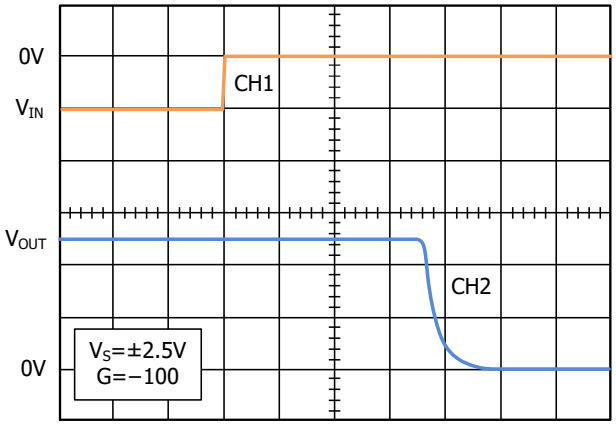
Small−Signal Step Response



CH1: 1V/Div M: 1us/Div

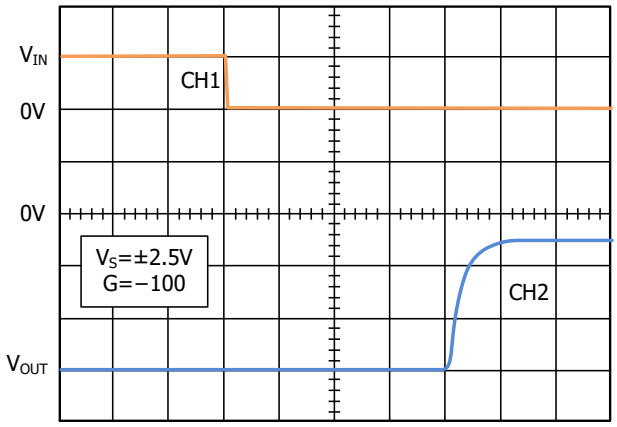
Large−Signal Step Response

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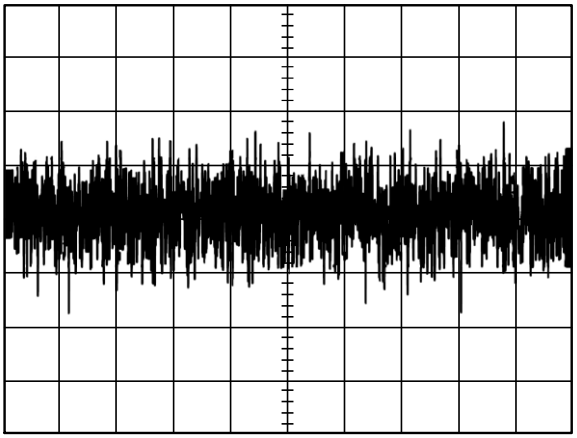
CH1: 200mV/Div CH2: 1V/Div M: 200ns/Div

Positive Overvoltage Recovery



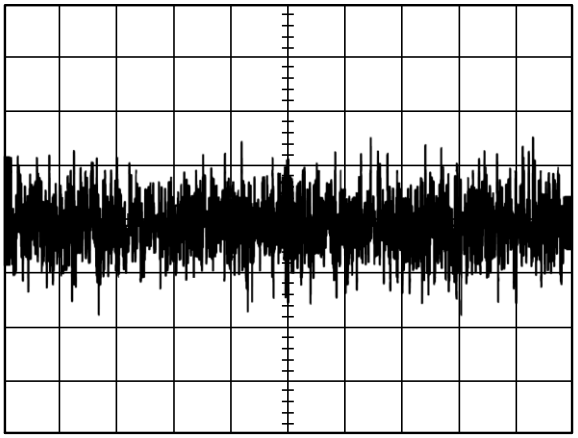
CH1: 200mV/Div CH2: 1V/Div M: 200ns/Div

Positive Overvoltage Recovery



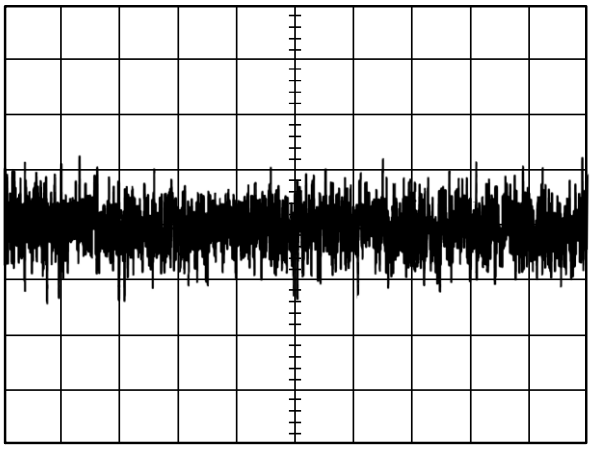
CH1: 200nV/Div M:10s/Div

0.01Hz To 10Hz Noise at Vs = 5V



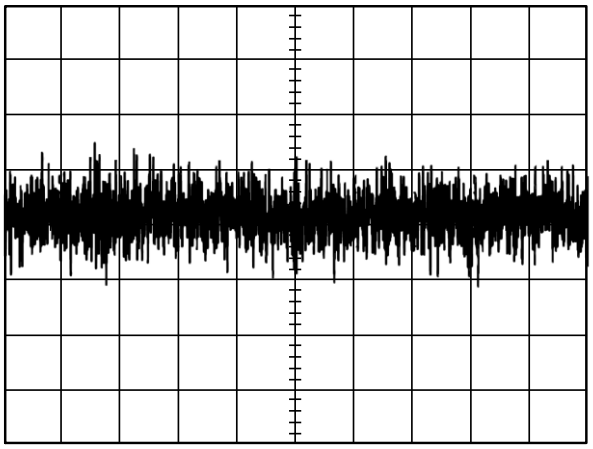
CH1: 400nV/Div M:10s/Div

0.01Hz to 10Hz Noise at Vs = 2.7V



CH1: 100nV/Div M:10s/Div

0.01Hz to 10Hz Noise at Vs = 5V



CH1: 200nV/Div M:10s/Div

0.01Hz to 10Hz Noise at Vs = 2.7V

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APPLICATION INFORMATION

The robust design of the AT8557 family provides ease-of-use to the circuit designer due to the unity-gain stability, integrated RFI/EMI rejection filter, no phase reversal in overdrive conditions, and high electrostatic discharge (ESD) protection. They use auto zeroing techniques to provide low offset voltage and very low drift over time and temperature. Good layout practice mandates use of a 0.1μF capacitor placed closely across the supply pins. For lowest offset voltage and precision performance, circuit layout and mechanical conditions should be optimized. Avoid temperature gradients that create thermoelectric effects in thermocouple junctions formed from connecting dissimilar conductors. These thermally-generated potentials can be made to cancel by assuring that they are equal on both input terminals.

- Use low thermoelectric-coefficient connections (avoid dissimilar metals).
- Thermally isolate components from power supplies or other heat-sources.
- Shield op amp and input circuitry from air currents, such as cooling fans.

Following these guidelines will reduce the likelihood of junctions being at different temperatures, which can cause thermoelectric voltages of 0.1μV/°C or higher, depending on materials used.

OPERATING VOLTAGE

The AT8557 operational amplifier family 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. In addition, many specifications apply from –40°C to 125°C. Power supply pins must be bypassed with 0.1μF ceramic capacitors. Parameters that vary over supply voltage or temperature are shown in the Typical Characteristics section of this datasheet.

MAXIMIZING PERFORMANCE THROUGH PROPER LAYOUT

For best operational performance of the device, use good printed-circuit board (PCB) layout practices, including: Noise can propagate into analog circuitry through the power pins of the circuit as a whole and the operational amplifier. Bypass capacitors are used to reduce the coupled noise by providing low-impedance power sources local to the analog circuitry. Connect low ESR, 0.1μF ceramic bypass capacitors between each supply pin and ground, placed as close to the device as possible. A single bypass capacitor from V+ to ground is applicable for single supply applications. Place the external components as close to the device as possible. Place the external components as close to the device as possible. Keep the length of input traces as short as possible. Always remember that the input traces are the most sensitive part of the circuit. Consider a driven, low-impedance guard ring around the critical traces.

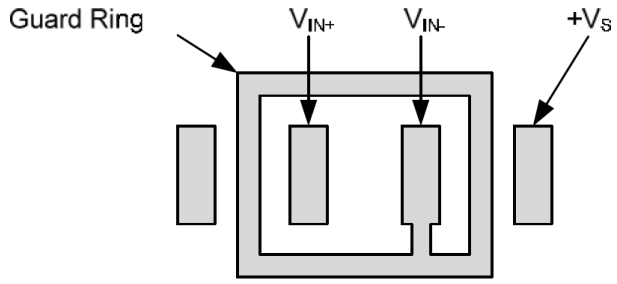
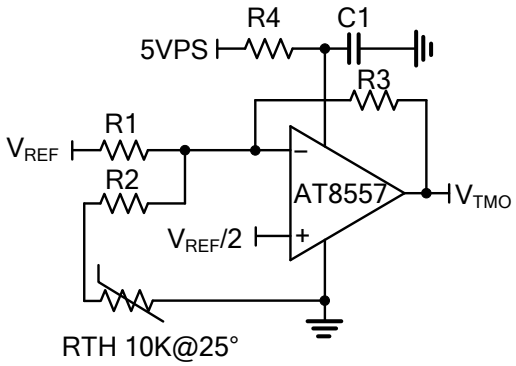


Figure 2. The Layout of Guard Ring

TYPICAL APPLICATION



R1, R2, R3 are TEC temperature control parameters, see Figure 4. Required temperature parameters can

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be achieved through adjusting R1, R2 and R3, thus TEC controller can detect the temperature range that users require.

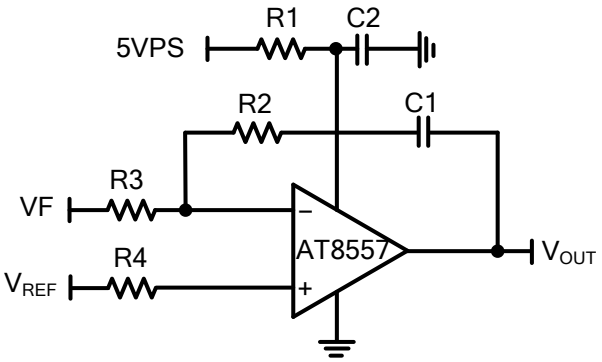
In different temperature ranges, R1, R2 and R3 have different corresponding resistances. R1, R2 and R3 can be determined by:

$$R1 = R_{MID} + \frac{R_{MID}(R_{LOW} + R_{HIGH}) - 2 * R_{LOW} * R_{HIGH}}{R_{LOW} + R_{HIGH} - 2 * R_{MID}}$$

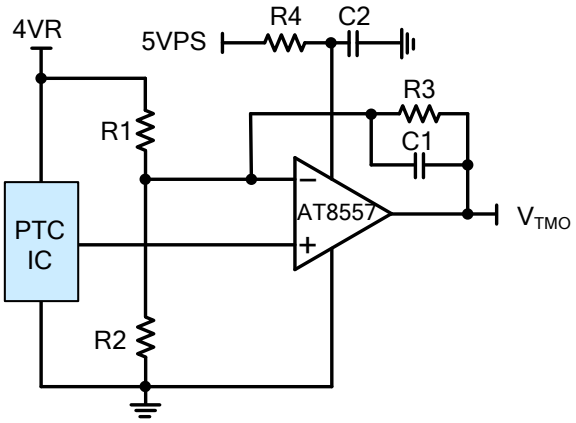
$$R2 = R1 - R_{MID}$$

$$R3 = \frac{R1(R1 + R_{LOW} - R_{MID})}{R_{LOW} - R_{MID}}$$

EA



Positive Coefficient



$V_{TMO}(T_L) = 0.1V$, $V_{TMO}(T_U) = 3.9V$

$$G = \frac{\Delta V_{TMO}}{\Delta V_{PTCIC}} = \frac{V_{TMO}(T_U) - V_{TMO}(T_L)}{V_{PTCIC}(T_U) - V_{PTCIC}(T_L)}$$

$$G = \frac{R3}{R1//R2} + 1$$

$$V_{PTCIC}(T_M) = \frac{V_{PTCIC}(T_U) + V_{PTCIC}(T_L)}{2}$$

$$V_{PTCIC} = V_{PTCIC}(T_M),\ V_{TMO} = \frac{3.9V + 0.1V}{2} = 2V$$

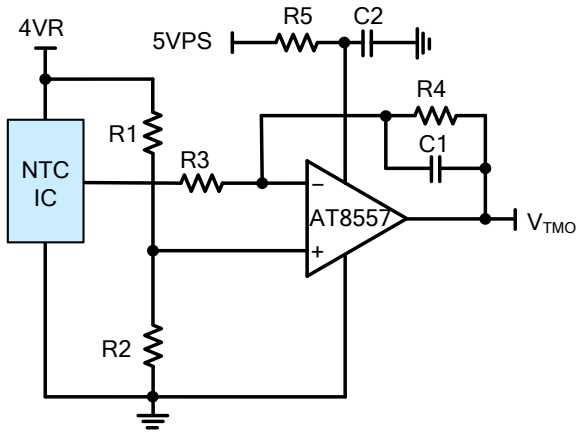
$$\frac{V_{PTCIC}(T_M)}{R2} = \frac{2V - V_{PTCIC}(T_M)}{R3} + \frac{4V - V_{PTCIC}(T_M)}{R1}$$

R3=20kΩ

$$R2 = \frac{R3}{[4V - V_{PTCIC}(T_M)] \times G - 2}$$

$$R1 = \frac{R3}{G - 1 - \frac{R3}{R2}} = \frac{R2 \times R3}{R2 \times (G - 1) - R3}$$

Negative Coefficient



$V_{TMO}(T_L) = 0.1V$, $V_{TMO}(T_U) = 3.9V$

$$G = \frac{\Delta V_{TMO}}{\Delta V_{NTCIC}} = \frac{V_{TMO}(T_U) - V_{TMO}(T_L)}{V_{NTCIC}(T_U) - V_{NTCIC}(T_L)}$$

$$G = \frac{R4}{R3} \qquad R3 = \frac{R4}{G}$$

R4 =20kΩ ~ 200kΩ

$$V_{NTCIC}(T_M) = \frac{V_{NTCIC}(T_U) + V_{NTCIC}(T_L)}{2}$$

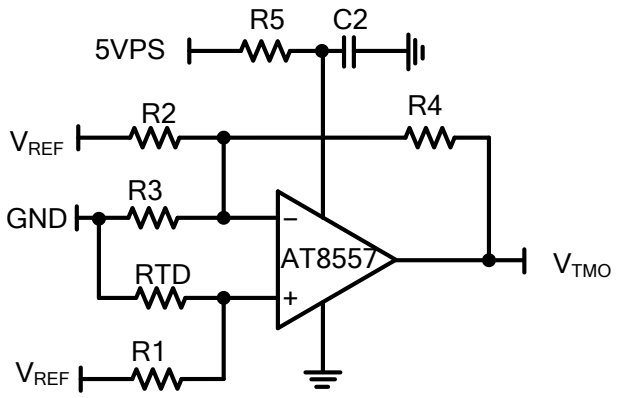
$$\frac{[2V - V_{NTCIC}(T_M)] \times R3}{R3 + R4} + V_{NTCIC}(T_M) = \frac{4V \times R2}{R1 + R2}$$

R2=10k

$$R1 = \frac{40 \times (1 + G)}{2 - V_{NTCIC}(T_M)} - 10$$

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RTD



$R_{TD} = R_0 \times (1+0.00385T)$

e.g. $R_0 = 1k\Omega$

When T = 10°C, $R_{TD}(10) = 1.0385k\Omega$

When T = 40°C, $R_{TD}(40) = 1.154k\Omega$

Choose R1

A. $P_{RTD} \leq 1mW$, $R_{TD} = 1000\Omega$

$P_{RTD} = (I_{RTD})^2 \times 1000\Omega = 0.001W$

$$I_{RTD} = 1mA = \frac{4VR}{R1 + R_{TD}} = \frac{4}{R1 + 1k} \Rightarrow R1 = 3k\Omega$$

B. $P_{RTD} \leq 1mW$, $R_{TD} = 100\Omega$

$P_{RTD} = (I_{RTD})^2 \times 100\Omega = 0.001W$

$$I_{RTD} = 3.16mA = \frac{4VR}{R1 + R_{TD}} = \frac{4}{R1 + 0.1k}$$

$R1 = 1.15k\Omega$

$$V_{TMO} = \frac{4 \times R_{TD}}{R1 + R_{TD}} \times \left[1 + \frac{R4 \times (R2 + R3)}{R2 \times R3}\right] - \frac{4 \times R4}{R2}$$

I. When T = 10°C, R1 = 3kΩ, $R_{TD}(T_L) = 1.0385k\Omega$,

$$0.93 = \frac{R4 \times (2.97R3 - 1.03R2)}{R2 \times R3}$$

When T = 40°C, R1 = 3kΩ, $R_{TD}(T_U) = 1.154k\Omega$,

$$2.79 = \frac{R4 \times (1.11R2 - 2.89R3)}{R2 \times R3}$$

II. When T = 10°C, R1 = 1.15kΩ, $R_{TD}(T_L) = 1.0385k\Omega$,

$$1.8 = \frac{R4 \times (2.1R3 - 1.9R2)}{R2 \times R3}$$

When T = 40°C, R1 = 1.15kΩ, $R_{TD}(T_U) = 1.154k\Omega$,

$$1.9 = \frac{2 \times R4 \times (R2 - R3)}{R2 \times R3}$$

To achieve the required V_{TMO} outputs at the three different setting point temperatures in the Temperature Network, use the equation:

When T = LOW, RTD = RTD_L, TMO = 0.1V, $V_1 = V_{1L}$

When T = HIGH, RTD = RTD_H, TMO = 4.0V, $V_1 = V_{1H}$

$\Delta TMO = 4V - 0.1V = 3.9V$

$\Delta V1 = V_{1H} - V_{1L}$

$$G = \frac{\Delta TMO}{\Delta V1} = 1 + \frac{R4 \times (R2 + R3)}{R2 \times R3}$$

$RTD = R_0 \times (1+0.00385T)$

e.g. $R_0 = 1k\Omega$

$$V1 = 4.096V \times \frac{RTD}{R1 + RTD}$$

$V_{1L} = 0.5V$

$$R1 = RTD_L \times \frac{4.096V}{V_{1L}} - RTD_L$$

$R2 = R1$, $R3 = RTD_L$

$$R4 = (G - 1) \times \frac{R2 \times R3}{R2 + R3}$$

For example, setting the high set-point temperature at 60°C and the low set-point temperature at 0°C.Use $RTD = R_0 \times (1+0.00385T)$, (e.g. $R_0 = 1k\Omega$).

$RTD_L = R_{TD}(10°C) = 1.0k\Omega$

$RTD_H = R_{TD}(60°C) = 1.231k\Omega$

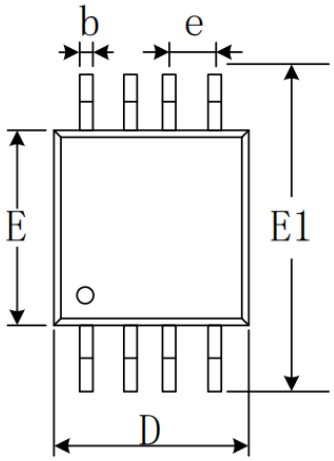
$R_1 = 7.192k\Omega$ $R_2 = R_1 = 7.192k\Omega$

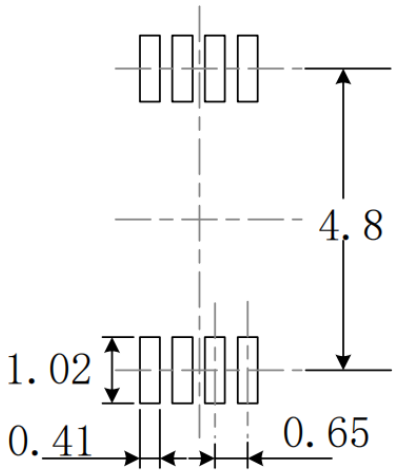
$R_3 = RTD_L = 1.0k\Omega$, $R_4 = 32.308k\Omega$

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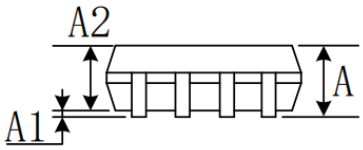
OUTLINE DIMENSIONS

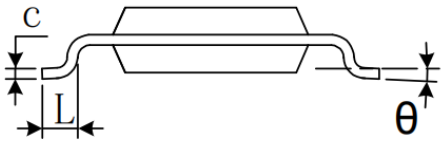
MSOP-8





RECOMMENDED LAND PATTERN (Unit: mm)

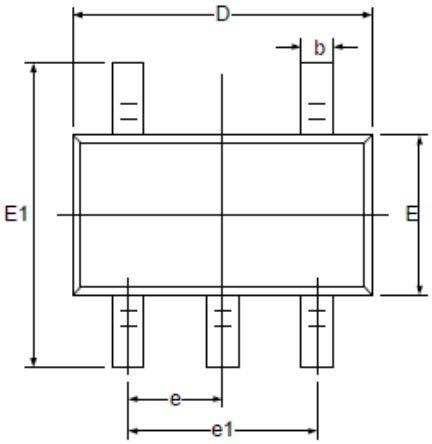


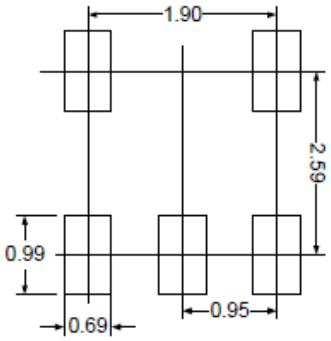


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	0.820	1.100	0.032	0.043
A1	0.020	0.150	0.001	0.006
A2	0.750	0.950	0.030	0.037
b	0.250	0.380	0.010	0.015
c	0.090	0.230	0.004	0.009
D	2.900	3.100	0.114	0.122
e	0.650(BSC)		0.026(BSC)	
E	2.900	3.100	0.114	0.122
E1	4.750	5.050	0.187	0.199
L	0.400	0.800	0.016	0.031
θ	0°	6°	0°	6°

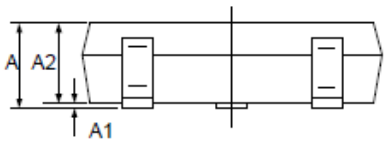
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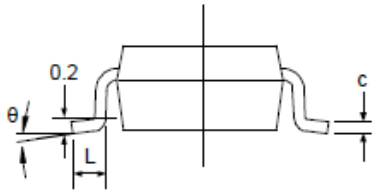
SOT23-5





RECOMMENDED LAND PATTERN (Unit: mm)

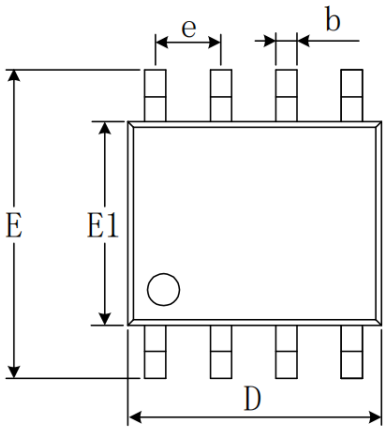


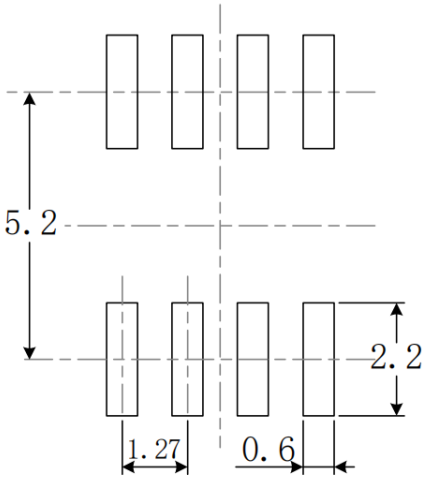


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950(BSC)		0.037(BSC)	
e1	1.800	2.000	0.071	0.079
L	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°

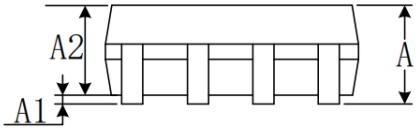
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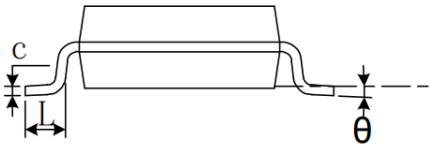
SOIC-8





RECOMMENDED LAND PATTERN (Unit: mm)





Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	1.350	1.750	0.063	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.007	0.010
D	4.800	5.000	0.189	0.197
e	1.270(BSC)		0.050(BSC)	
E	5.800	6.200	0.228	0.244
E1	3.800	4.000	0.150	0.157
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°

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