

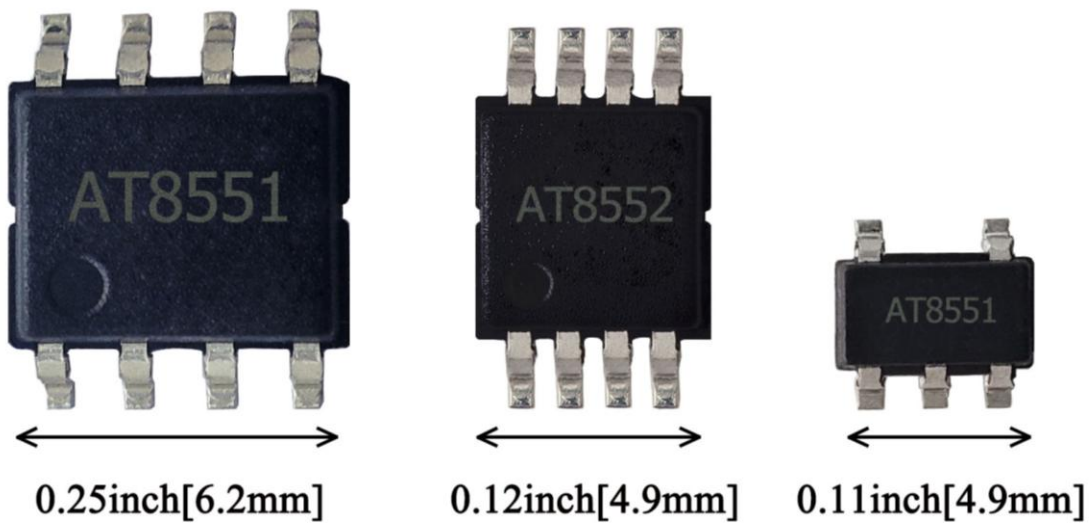
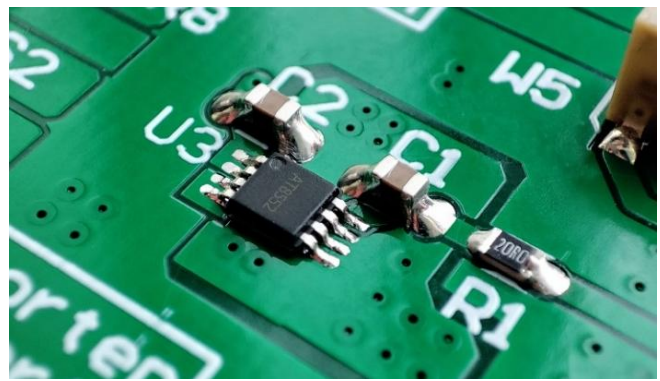
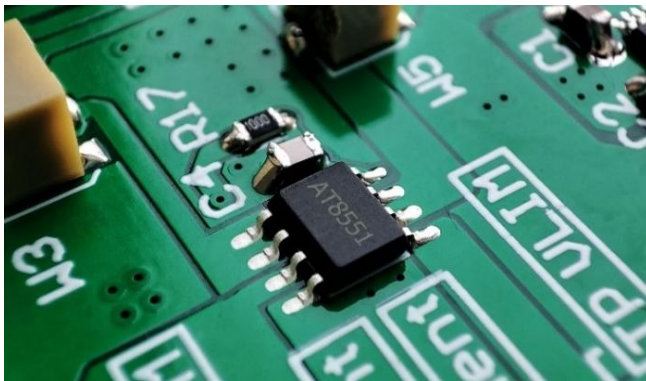


Figure 1. Physical Photos of AT8551



ORDERING GUIDE

Online Stores		Commission Fee	Unit Price (June 2024)	Buy Now
	shop.analogtechnologies Our own online store	Zero sale commission	\$0.90/100PCs	 *
	SMTZone Our own online store	Zero sale commission	\$0.90/100PCs	 *
	Digikey	≈32% sale commission	\$1.19/100PCs	 *



Table 1. AT8551/8552 vs. AD8551/8552

Parameter	AT8551	AD8551
Offset Voltage	<5 μ V	10 μ V
Noise (0.01Hz to 10Hz)	<0.75 μ V _{P-P}	1 μ V _{P-P}
Slew Rate	2.7V/ μ s	0.4 μ V/ μ s
Bandwidth	4.5MHz	1.5MHz
Price	100~499pcs	\$0.90
	>1000pcs	\$0.78
		\$2.69
		\$2.06

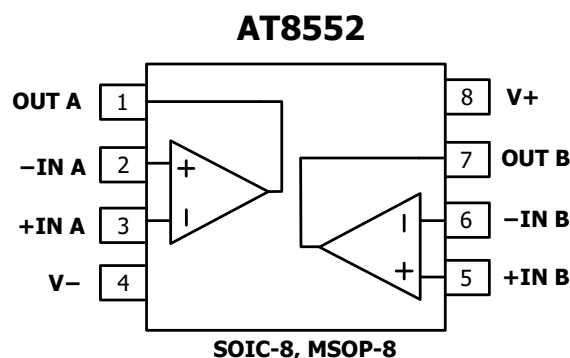
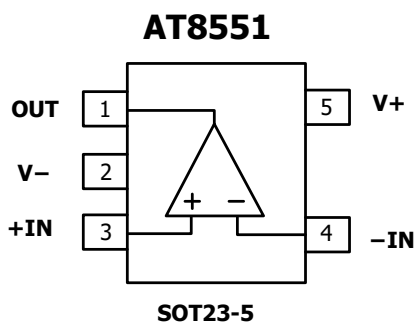
FEATURES

- Upgraded Drop-in Replacement for AD8551
- Low Offset Voltage: 1 μ V (typ) 5 μ V (max)
- Input Offset Drift: 0.005 μ V/ $^{\circ}$ C (max)
- High Gain Bandwidth Product: 4.5MHz
- Rail-to-Rail Input and Output
- High Gain, CMRR & PSRR: $\geq$ 130dB
- High Slew Rate: 2.7V/ μ s
- Low Noise: 0.75 μ V_{P-P} (0.01~10Hz)
- Low Power Consumption: 640 μ A/op amp
- Overload Recovery Time: 1 μ s
- Low Supply Voltage: +2.7V to +5.5V
- No External Capacitors Required
- Extended Temperature: -40 $^{\circ}$ C to +125 $^{\circ}$ C

APPLICATIONS

- Temperature & Pressure Sensors Amplifier

PIN CONFIGURATIONS



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

DESCRIPTION

This AT855x family includes single (AT8551) and dual (AT8552) general purpose CMOS operational amplifiers that provides ultralow noise, offset and power. The AT8551 use auto-zero techniques to simultaneously provide very low offset voltage (5 μ V 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 4.5MHz and slew rate of 2.7V/ μ s.

This op amp operates as low as +2.7V ($\pm$ 1.35) and up to +5.5V ($\pm$ 2.75V). The AT8551 single amplifier is available in 5-lead SOT23, 8-lead MSOP8 and 8-lead SOIC packages, The AT8552 dual amplifier is available in 8-lead SOIC and 8-lead MSOP8 narrow surface mount packages. The AT8551/AT8552 (dual version) are specified for the extended industrial and automotive temperature range (-40 $^{\circ}$ C to 125 $^{\circ}$ C).



PIN DESCRIPTION

Descriptions of the pins are listed in Table 2 (single op amps) and Table 3 (dual op amps).

Table 2: Pin Function Table for Single OP AMPS

AT8551	Symbol	Description
SOT23-5		
1	OUT	Analog Output
2	V–	Negative Power Supply
3	+IN	Noninverting Input
4	–IN	Inverting Input
5	V+	Positive Power Supply
-	NC	No Internal Connection

Table 3: Pin Function Table for Dual OP AMPS

AT8552		Symbol	Description
MSOP-8	SOIC-8		
1	1	OUT A	Analog Output (Op Amp A)
2	2	–IN A	Inverting Input (Op Amp A)
3	3	+IN A	Noninverting Input (Op Amp A)
4	4	V–	Negative Power Supply
5	5	+IN B	Noninverting Input (Op Amp B)
6	6	–IN B	Inverting Input (Op Amp B)
7	7	OUT B	Analog Output (Op Amp B)
8	8	V+	Positive Power Supply

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.

Package Type	8-Lead MSOP	8-Lead SOIC	5-Lead SOT23	Unit
R _{θJA} Junction-to-ambient thermal resistance	180.3	140.1	220.8	°C/W
R _{θJC} (top) Junction-to-case (top) thermal resistance	48.1	89.8	97.5	°C/W
R _{θJB} 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

**ELECTRICAL CHARACTERISTICS**

Limits apply over the specified temperature range: $T_A = -40^{\circ}\text{C}$ to $+125^{\circ}\text{C}$.

(At $T_A = +25^{\circ}\text{C}$, $V_S = 5\text{V}$, $R_L = 10\text{k}\Omega$ 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}	$V_{CM} = V_S/2$ $T_A = -40^{\circ}\text{C}$ to $+125^{\circ}\text{C}$		1	5	μV
Input Bias Current	I_B	$V_{CM} = V_S/2$ $T_A = -40^{\circ}\text{C}$ to $+125^{\circ}\text{C}$		50		pA
Input Offset Current	I_{OS}	$T_A = -40^{\circ}\text{C}$ to $+125^{\circ}\text{C}$		10		pA
Input Voltage Range	V_{IN}		2.7		5.5	V
Common-Mode Voltage Range	V_{CM}		$(V-) - 0.1$		$(V+) + 0.1$	V
Common-Mode Rejection Ratio	CMRR	$(V-) - 0.1\text{V} < V_{CM} < (V+) + 0.1\text{V}$ $T_A = -40^{\circ}\text{C}$ to $+125^{\circ}\text{C}$	110	130		dB
Offset Voltage Drift	$\Delta V_{OS}/\Delta T$	$T_A = -40^{\circ}\text{C}$ to $+125^{\circ}\text{C}$		0.005	0.05	$\mu\text{V}/^{\circ}\text{C}$
Channel Separation, dc				0.1		$\mu\text{V}/\text{V}$
Open-Loop Gain	A_{OL}	$R_L = 10\text{k}\Omega$, $V_O = 0.3\text{V}$ to 4.7V $T_A = -40^{\circ}\text{C}$ to $+125^{\circ}\text{C}$		110	130	dB
INPUT CAPACITANCE						
Differential				1		pF
Common-Mode				5		pF
OUTPUT CHARACTERISTICS						
Output Voltage High	V_{OH}	$R_L = 100\text{k}\Omega$ to GND $T_A = -40^{\circ}\text{C}$ to $+125^{\circ}\text{C}$	4.99	4.998		V
		$R_L = 10\text{k}\Omega$ to GND $T_A = -40^{\circ}\text{C}$ to $+125^{\circ}\text{C}$	4.95	4.98		V
Output Voltage Low	V_{OL}	$R_L = 100\text{k}\Omega$ to $V+$ $T_A = -40^{\circ}\text{C}$ to $+125^{\circ}\text{C}$		1	10	mV
		$R_L = 10\text{k}\Omega$ to $V+$ $T_A = -40^{\circ}\text{C}$ to $+125^{\circ}\text{C}$		10	30	mV
Output Short-Circuit Limit Current	I_{SC}	$T_A = -40^{\circ}\text{C}$ to $+125^{\circ}\text{C}$		50		mA

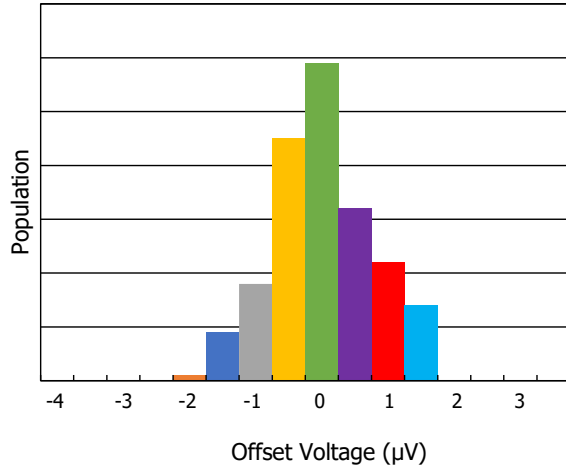


Parameter	Symbol	Test Conditions	Min.	Typ.	Max.	Unit
POWER SUPPLY						
Power Supply Rejection Ratio	PSRR	$V_S = +2.7V \text{ to } +5.5V, V_{CM} = 0$ $T_A = -40^\circ\text{C to } +125^\circ\text{C}$	110	130		dB
Quiescent Current/Amplifier	I_Q	$V_O = 0$ $T_A = -40^\circ\text{C to } +125^\circ\text{C}$		640	870	μA
Supply Voltage Range	V_{IN}		2.7		5.5	V
DYNAMIC PERFORMANCE						
Slew Rate	SR	$G=+1$		2.7		V/ μs
Gain Bandwidth Product	GBP			4.5		MHz
Overload Recovery Time				1		μs
NOISE PERFORMANCE						
Voltage Noise	$e_n \text{ p-p}$	0.01Hz to 10Hz		0.75		$\mu\text{V p-p}$
	$e_n \text{ p-p}$	0.01Hz to 1Hz		0.22		$\mu\text{V p-p}$
Voltage Noise Density	e_n	$f = 1\text{kHz}$		35		nV/ $\sqrt{\text{Hz}}$
Current Noise Density	i_n	$f = 10\text{Hz}$		1.5		fA/ $\sqrt{\text{Hz}}$

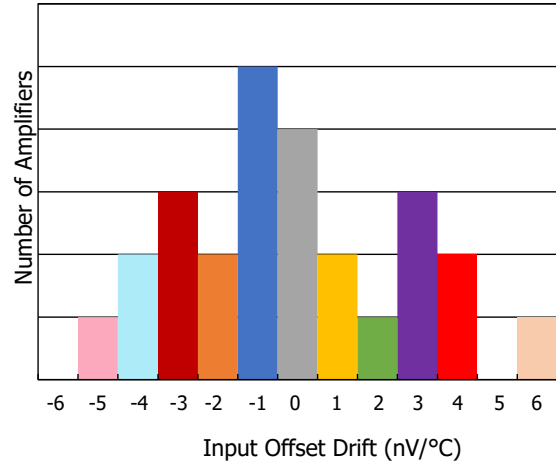


TYPICAL CHARACTERISTICS

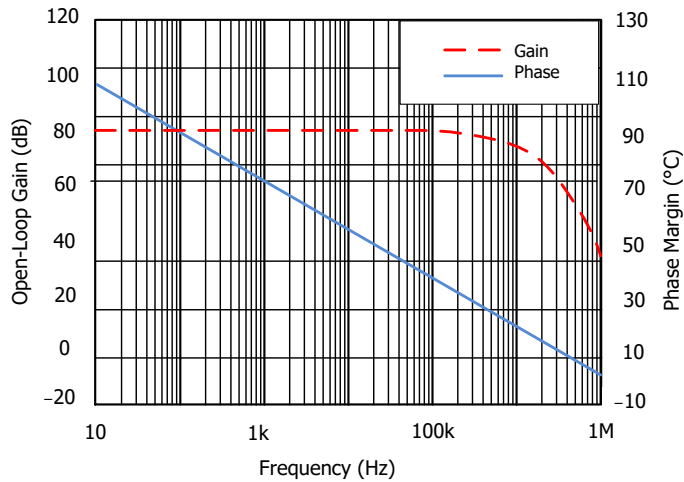
At $T_A = +25^\circ\text{C}$, $V_S = 5\text{V}$, $R_{\text{LOAD}} = 10\text{k}\Omega$ connected to $V_S/2$, $V_{\text{OUT}} = V_S/2$, unless otherwise noted.



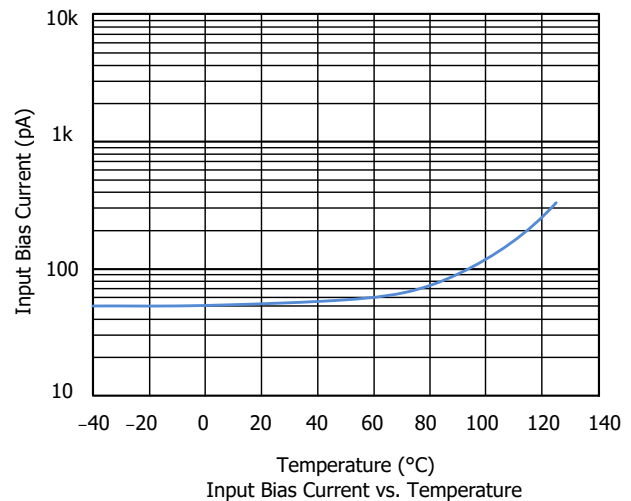
Offset Voltage Production Distribution



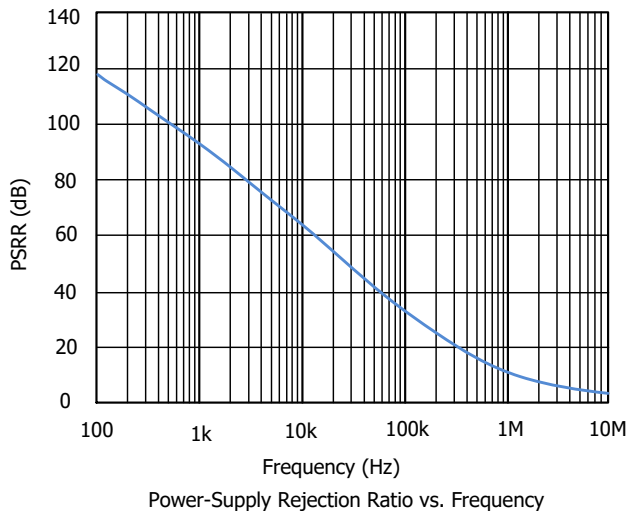
Input Offset Drift Production Distribution



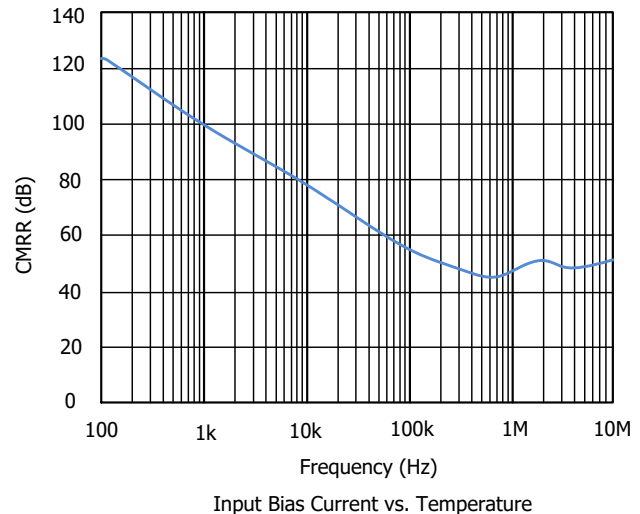
Open-Loop Gain and Phase vs. Frequency



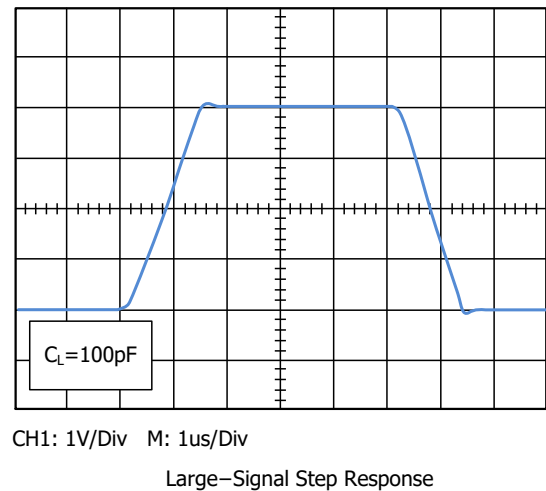
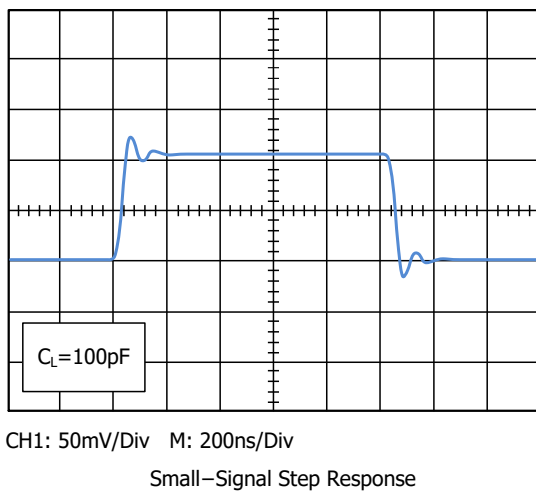
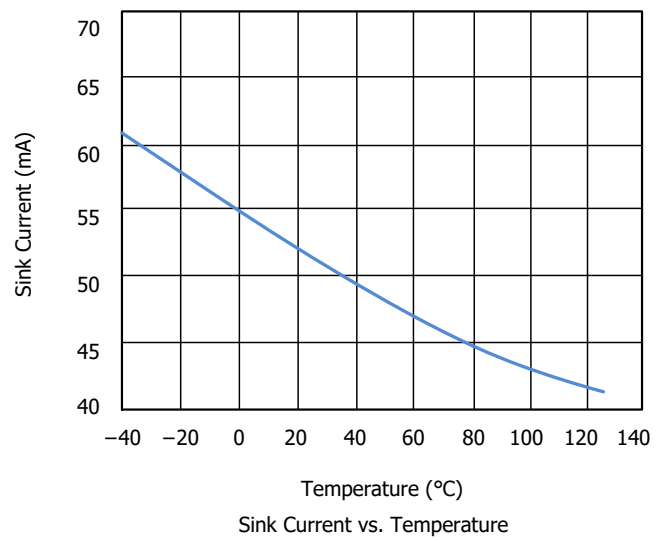
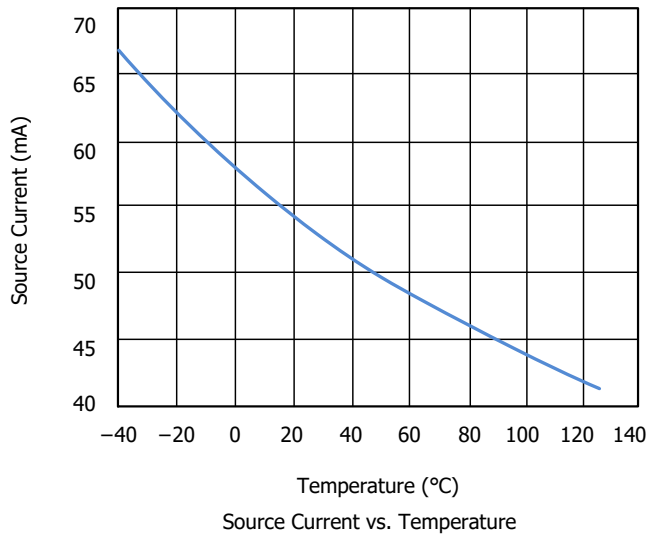
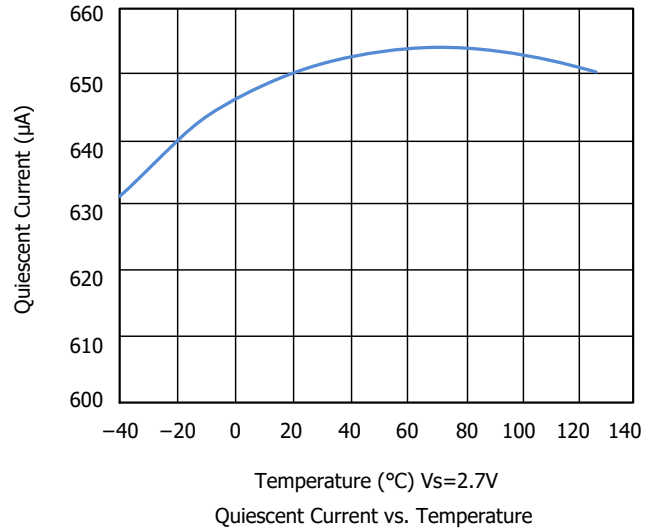
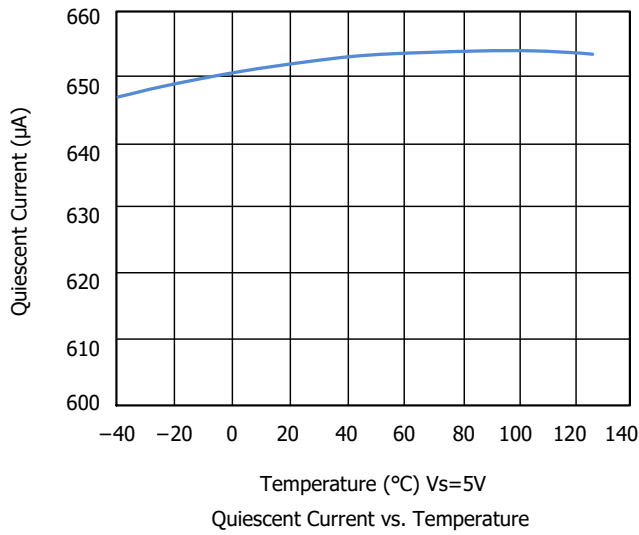
Input Bias Current vs. Temperature

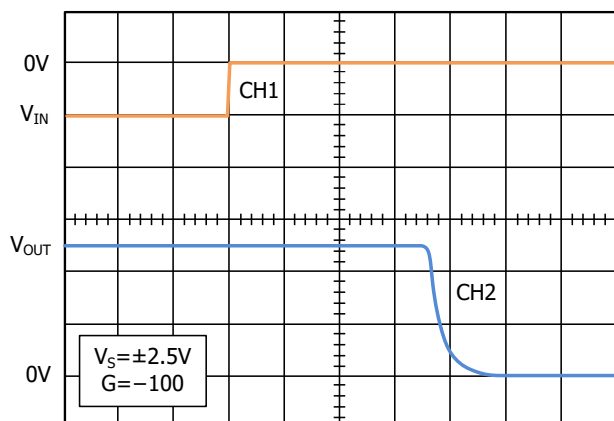


Power-Supply Rejection Ratio vs. Frequency



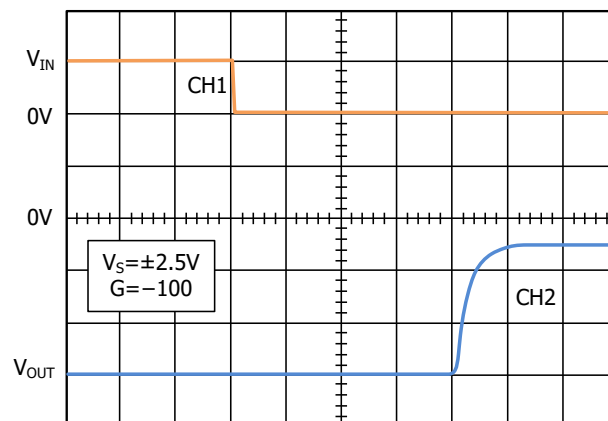
Input Bias Current vs. Temperature





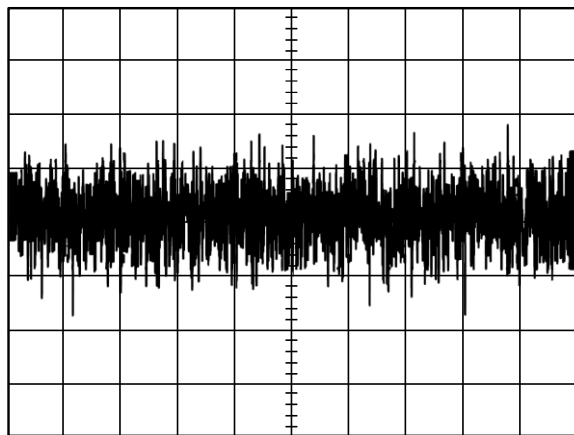
CH1: 200mV/Div CH2: 1V/Div M: 200ns/Div

Positive Overvoltage Recovery



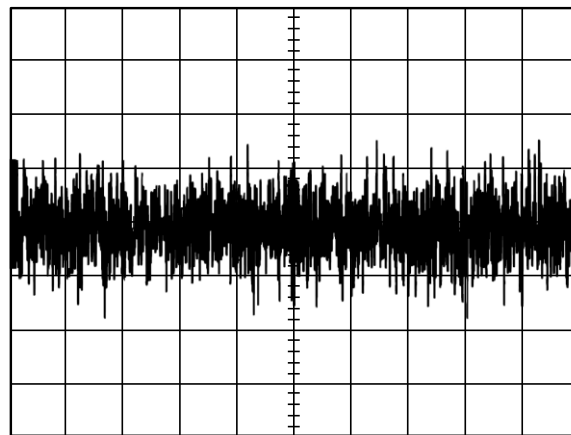
CH1: 200mV/Div CH2: 1V/Div M: 200ns/Div

Positive Overvoltage Recovery



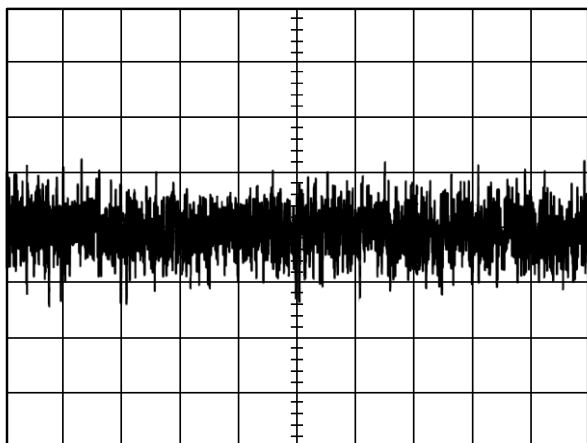
CH1: 200nV/Div M: 10s/Div

0.01Hz To 10Hz Noise at $V_S = 5V$



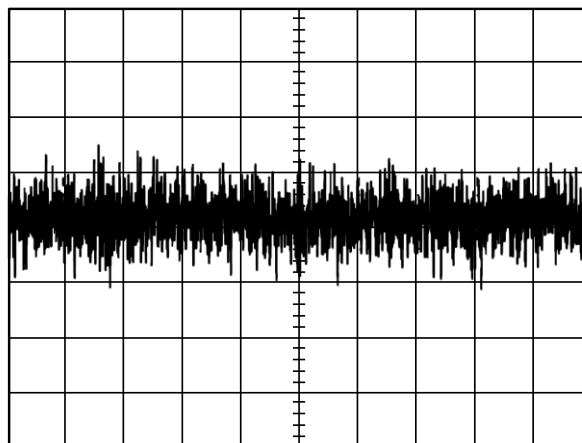
CH1: 400nV/Div M: 10s/Div

0.01Hz to 10Hz Noise at $V_S = 2.7V$



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

0.01Hz to 10Hz Noise at $V_S = 5V$



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

0.01Hz to 10Hz Noise at $V_S = 2.7V$

APPLICATION INFORMATION

The robust design of the AT855x 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 0.1 μ F 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 0.1 μ V/ $^{\circ}$ C or higher, depending on materials used.

OPERATING VOLTAGE

The AT8551/AT8552 operational amplifier family operate over a power supply range of +2.7V to +5.5V (± 1.35 V to ± 2.75 V). 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 0.1 μ F 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, 0.1 μ F 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.

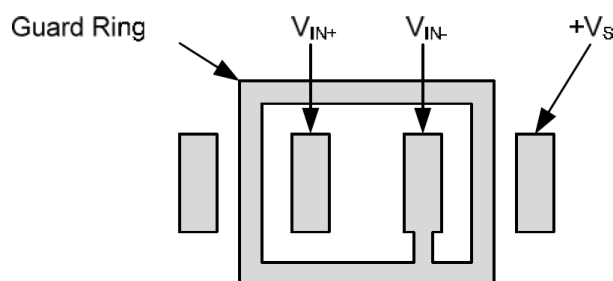
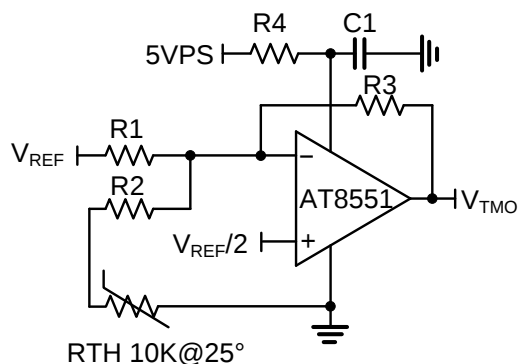


Figure 2. The Layout of Guard Ring

TYPICAL APPLICATION



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



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

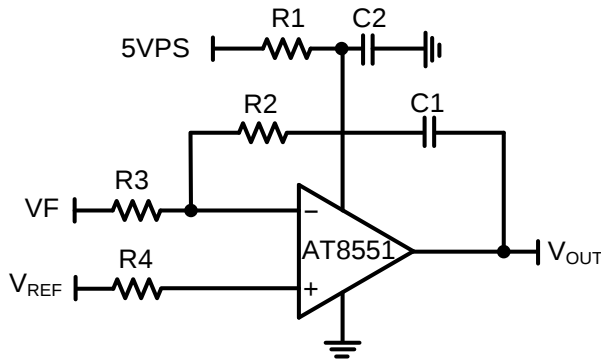
In different temperature ranges, R1, R2 and R3 have different corresponding resistances. R1, R2 and R3 can be determined by:

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

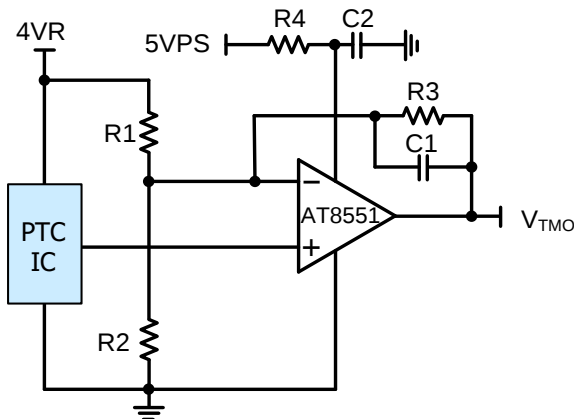
$$R2 = R1 - R_{MID}$$

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

EA



Positive Coefficient



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

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

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

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

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

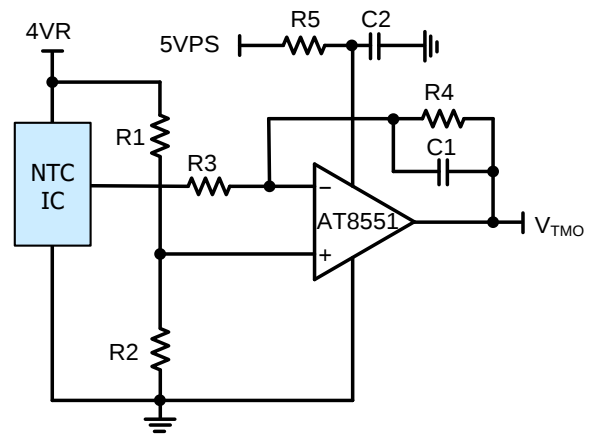
$$\frac{V_{PTCIC}(T_M)}{R2} = \frac{2V - V_{PTCIC}(T_M)}{R3} + \frac{4V - V_{PTCIC}(T_M)}{R1}$$

$$R3 = 20k\Omega$$

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

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

Negative Coefficient



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

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

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

$$R4 = 20k\Omega \sim 200k\Omega$$

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

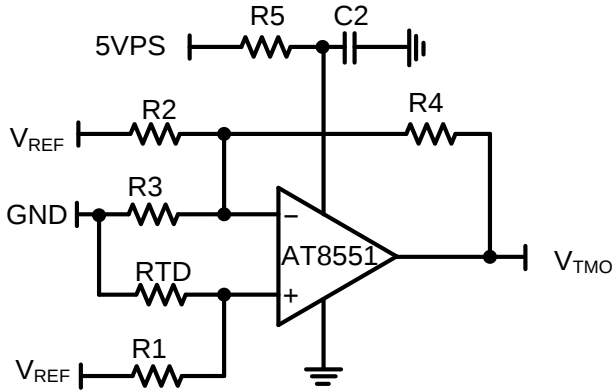
$$\frac{[2V - V_{NTCIC}(T_M)] \times R3}{R3 + R4} + V_{NTCIC}(T_M) = \frac{4V \times R2}{R1 + R2}$$

$$R2 = 10k$$

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



RTD



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

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

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

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

Choose R_1

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

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

$$I_{RTD} = 1mA = \frac{4VR}{R_1 + R_{TD}} = \frac{4}{R_1 + 1k} \Rightarrow R_1 = 3k\Omega$$

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

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

$$I_{RTD} = 3.16mA = \frac{4VR}{R_1 + R_{TD}} = \frac{4}{R_1 + 0.1k}$$

$$R_1 = 1.15k\Omega$$

$$V_{TMO} = \frac{4 \times R_{TD}}{R_1 + R_{TD}} \times \left[1 + \frac{R_4 \times (R_2 + R_3)}{R_2 \times R_3} \right] - \frac{4 \times R_4}{R_2}$$

I. When $T = 10^\circ\text{C}$, $R_1 = 3k\Omega$, $R_{TD}(T_L) = 1.0385k\Omega$,

$$0.93 = \frac{R_4 \times (2.97R_3 - 1.03R_2)}{R_2 \times R_3}$$

When $T = 40^\circ\text{C}$, $R_1 = 3k\Omega$, $R_{TD}(T_U) = 1.154k\Omega$,

$$2.79 = \frac{R_4 \times (1.11R_2 - 2.89R_3)}{R_2 \times R_3}$$

II. When $T = 10^\circ\text{C}$, $R_1 = 1.15k\Omega$, $R_{TD}(T_L) = 1.0385k\Omega$,

$$1.8 = \frac{R_4 \times (2.1R_3 - 1.9R_2)}{R_2 \times R_3}$$

When $T = 40^\circ\text{C}$, $R_1 = 1.15k\Omega$, $R_{TD}(T_U) = 1.154k\Omega$,

$$1.9 = \frac{2 \times R_4 \times (R_2 - R_3)}{R_2 \times R_3}$$

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

When $T = \text{LOW}$, $R_{TD} = R_{TDL}$, $TMO = 0.1V$, $V_1 = V_{1L}$

When $T = \text{HIGH}$, $R_{TD} = R_{TDH}$, $TMO = 4.0V$, $V_1 = V_{1H}$

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

$$\Delta V_1 = V_{1H} - V_{1L}$$

$$G = \frac{\Delta TMO}{\Delta V_1} = 1 + \frac{R_4 \times (R_2 + R_3)}{R_2 \times R_3}$$

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

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

$$V_1 = 4.096V \times \frac{R_{TD}}{R_1 + R_{TD}}$$

$$V_{1L} = 0.5V$$

$$R_1 = R_{TDL} \times \frac{4.096V}{V_{1L}} - R_{TDL}$$

$$R_2 = R_1, R_3 = R_{TDL}$$

$$R_4 = (G - 1) \times \frac{R_2 \times R_3}{R_2 + R_3}$$

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

$$R_{TDL} = R_{TD}(10^\circ\text{C}) = 1.0k\Omega$$

$$R_{TDH} = R_{TD}(60^\circ\text{C}) = 1.231k\Omega$$

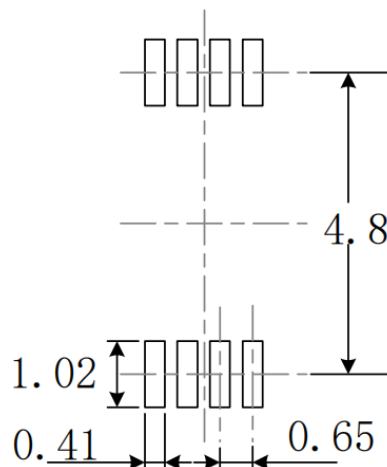
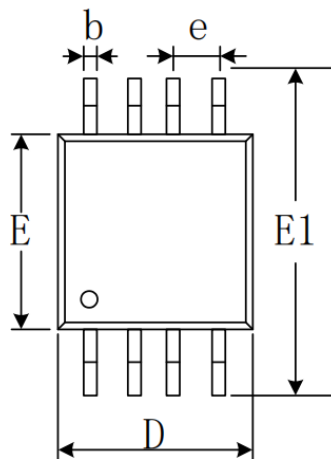
$$R_1 = 7.192k\Omega, R_2 = R_1 = 7.192k\Omega$$

$$R_3 = R_{TDL} = 1.0k\Omega, R_4 = 32.308k\Omega$$

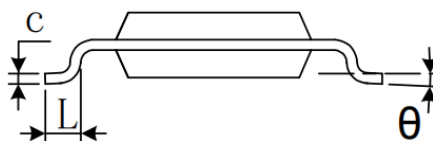
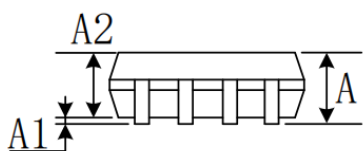


OUTLINE DIMENSIONS

MSOP-8



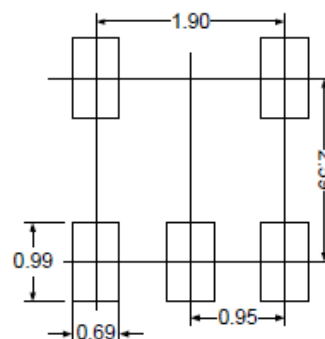
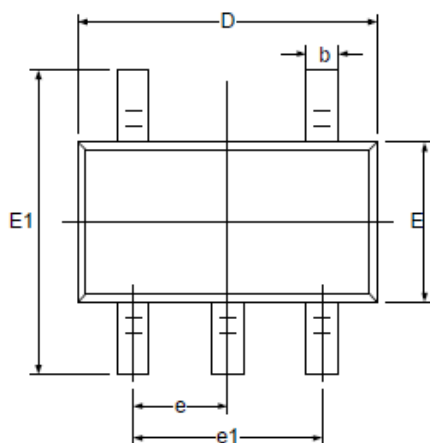
RECOMMENDED LAND PATTERN (Unit: mm)



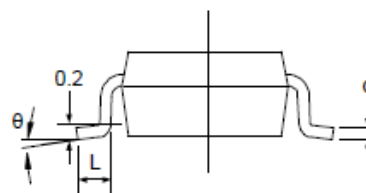
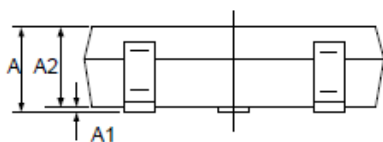
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	0.820	1.100	0.032	0.043
A1	0.020	0.150	0.001	0.006
A2	0.750	0.950	0.030	0.037
b	0.250	0.380	0.010	0.015
c	0.090	0.230	0.004	0.009
D	2.900	3.100	0.114	0.122
e	0.650(BSC)		0.026(BSC)	
E	2.900	3.100	0.114	0.122
E1	4.750	5.050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



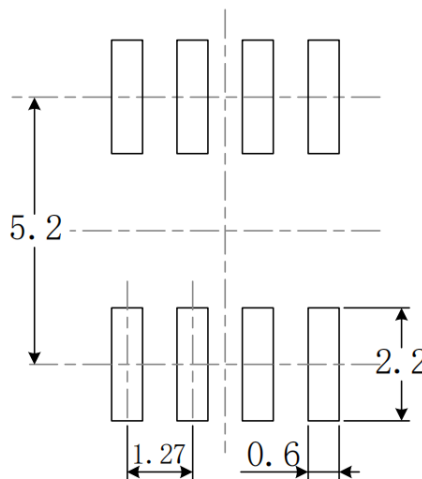
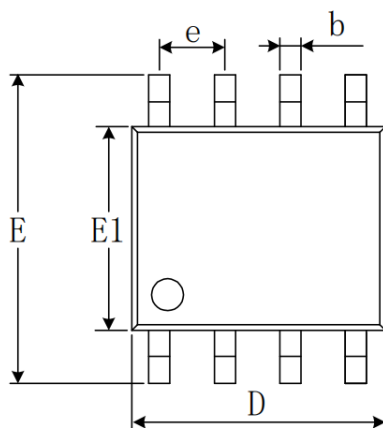
SOT23-5



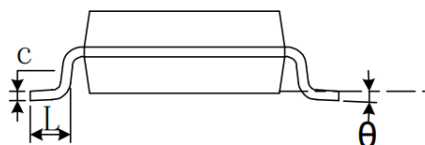
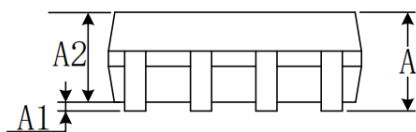
RECOMMENDED LAND PATTERN (Unit: mm)



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°



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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