Single Power Supply, Rail-to-Rail Input and Output, High-Precision Operational Amplifier

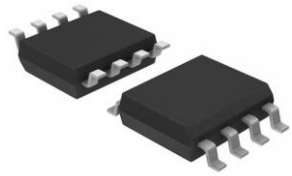
PRODUCT DESCRIPTION

The MS8551/8552/8554 is a rail-to-rail input and output, high-precision operational amplifier. It has ultra-low input offset voltage and bias current. The single power supply ranges from 1.8V to 5V.

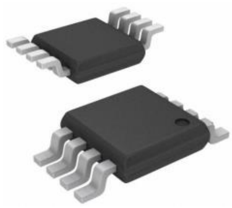
The MS8551/8552/8554 can be applied to temperature, position and pressure sensors, medical device as well as strain gauge amplifier.

The MS8551/8552/8554 ranges from -40°C to +125°C.

SOT23-5



SOP8



MSOP8

SOP14

FEATURES

- Low Offset Voltage: 1μV (TYP)
- Rail-to-Rail Input and Output
- Single Power Supply: 1.8V to 5.5V
- Voltage Gain: 145dB (TYP) (5V Operating Voltage)
- Power Supply Rejection Ratio: 120dB (TYP)
- Common-mode Rejection Ratio: 120dB (TYP)
- Ultra-low Input Bias Current: 10pA
- Low Operating Current: 800μA Each Channel (TYP)
- Overload Recovery Time: 50μs (5V Operating Voltage)
- No Need for Additional External Capacitor

PRODUCT SPECIFICATION

Part Number	Package	Marking
MS8551S	SOT23-5	8551S
MS8551	SOP8	MS8551
MS8552	SOP8	MS8552
MS8552M	MSOP8	MS8552M
*MS8554	SOP14	MS8554

*The package is not available temporarily. If necessary, please contact Hangzhou Ruimeng Sales Department Center.

PRODUCT GRADE

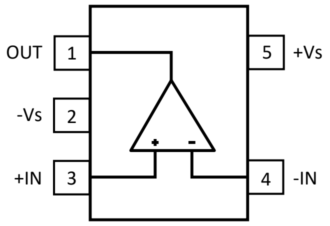
Grade	Offset Voltage (μV)	Condition
A	0-2	5V Power Supply
B	2-6	5V Power Supply
C	6-12	5V Power Supply

APPLICATIONS

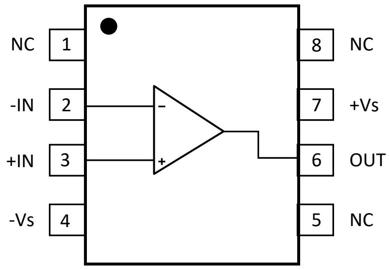
- Temperature Measurement
- Pressure Sensor
- High-precision Current Sense
- Electronic Weigh
- Strain Gauge Amplifier
- Medical Device
- Thermocouple Amplifier
- Handheld Test Device

PIN CONFIGURATION

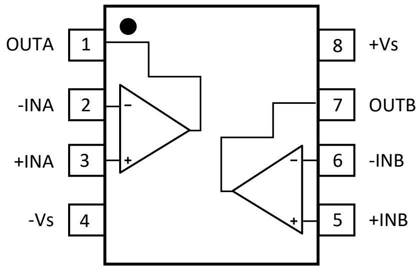
MS8551S



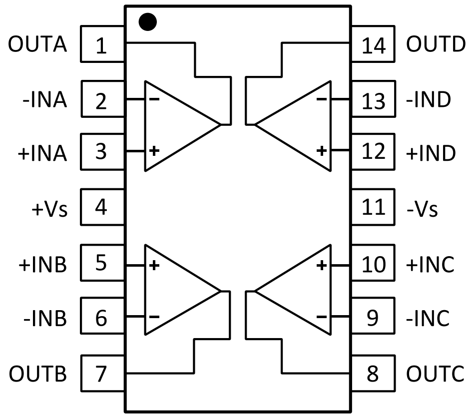
MS8551



MS8552/MS8552M



MS8554



PIN DESCRIPTION

Pin	Name	Type	Description
MS8551S			
1	OUT	O	Channel Output
2	-Vs	-	Negative Power Supply
3	+IN	I	Positive Input
4	-IN	I	Negative Input
5	+Vs	-	Positive Power Supply
MS8551			
1	NC	-	No Connection
2	-IN	I	Negative Input
3	+IN	I	Positive Input
4	-Vs	-	Negative Power Supply
5	NC	-	Not Connection
6	OUT	O	Channel Output
7	+Vs	-	Positive Power Supply
8	NC	-	No Connection
MS8552/MS8552M			
1	OUTA	O	Channel A Output
2	-INA	I	Negative Input (Channel A)
3	+INA	I	Positive Input (Channel A)
4	-Vs	-	Negative Power Supply
5	+INB	I	Positive Input (Channel B)
6	-INB	I	Negative Input (Channel B)
7	OUTB	O	Channel B Output
8	+Vs	-	Positive Power Supply
MS8554			
1	OUTA	O	Channel A Output
2	-INA	I	Negative Input (Channel A)
3	+INA	I	Positive Input (Channel A)
4	+Vs	-	Positive Power Supply
5	+INB	I	Positive Input (Channel B)
6	-INB	I	Negative Input (Channel B)
7	OUTB	O	Channel B Output
8	OUTC	O	Channel C Output
9	-INC	I	Negative Input (Channel C)
10	+INC	I	Positive Input (Channel C)
11	-Vs	-	Negative Power Supply
12	+IND	I	Positive Input (Channel D)
13	-IND	I	Negative Input (Channel D)
14	OUTD	O	Channel D Output

ABSOLUTE MAXIMUM RATINGS

Any exceeding absolute maximum rating application causes permanent damage to device. Because long-time absolute operation state affects device reliability. Absolute ratings just conclude from a series of extreme tests. It doesn't represent chip can operate normally in these extreme conditions.

Parameter	Symbol	Ratings	Unit
Power Supply	V_S	6	V
Input Voltage		GND ~ (+Vs) +0.3	V
Differential Input Voltage		-5 ~ 5 (or power supply, based on less value)	V
Junction Temperature		-65 ~ 150	°C
Operating Temperature	T_A	-40 ~ 125	°C
Storage Temperature	T_{STG}	-65 ~ 150	°C
Lead Temperature (Soldering, 10s)		260	°C
ESD (HBM)		±3000	V

ELECTRICAL CHARACTERISTICS (5V)

Unless otherwise noted, V_S=+5V, V_{CM}=+2.5V, V_O=+2.5V, T_A=25°C.

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Input Characteristics						
Input Offset Voltage	V_{OS}			1	5	μV
		-40°C ≤ T_A ≤ +125°C			10	
Input Bias Current	I_B			10	50	pA
		-40°C ≤ T_A ≤ +125°C			4	nA
Input Offset Current	I_{OS}	-40°C ≤ T_A ≤ +125°C		150	400	pA
Input Voltage			0		5	V
Common-mode Rejection Ratio	CMRR	V_{CM} = 0V to 5V	100	120		dB
		-40°C ≤ T_A ≤ +125°C	95	110		
Large-signal Gain	A_{VO}	R_L= 10kΩ, V_O= 0.3V to 4.7V	125	145		dB
		-40°C ≤ T_A ≤ +125°C	120	135		
Input Offset Voltage Drift	$\Delta V_{OS}/\Delta T_A$	-40°C ≤ T_A ≤ +125°C		0.04	0.05	μV/°C
Output Characteristics						
High-level Output Voltage	V_{OH}	R_L = 100kΩ to GND	4.99	4.998		V
		-40°C ≤ T_A ≤ +125°C	4.99	4.997		
		R_L = 10kΩ to GND	4.95	4.98		V
		-40°C ≤ T_A ≤ +125°C	4.95	4.975		
Low-level Output Voltage	V_{OL}	R_L = 100kΩ to +V_S		3	12	mV
		-40°C ≤ T_A ≤ +125°C		5	12	
		R_L = 10kΩ to +V_S		10	30	mV
		-40°C ≤ T_A ≤ +125°C		15	30	
Short-circuit Current	I_{SC}		40	70		mA
		-40°C ≤ T_A ≤ +125°C		75		
Power Supply						
Power Supply Rejection Ratio	PSRR	V_S =1.8V to 5.5V, -40°C ≤ T_A ≤ +125°C	110	120		dB
Quiescent Current/Amplifier	I_Q	V_O = 0		850	975	μA
		-40°C ≤ T_A ≤ +125°C		1000	1075	

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Dynamic Characteristics						
Gain Bandwidth Product	GBP	A_V = +100		3		MHz
Slew Rate	SR	A_V = +1, RL = 10kΩ		0.4		V/μs
Overload Recovery Time				0.05		ms
Noise Characteristics						
Voltage Noise	$e_{n\ P\text{-}P}$	0.1Hz to 10Hz		1.0		$\mu V_{p\text{-}p}$
Voltage Noise Density	e_n	f = 1kHz		42		$nV/\sqrt{Hz}$
Current Noise Density	i_n	f = 10Hz		2		$fA/\sqrt{Hz}$

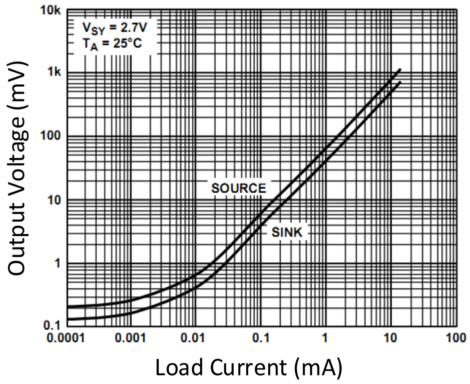
ELECTRICAL CHARACTERISTICS (2.7V)

Unless otherwise noted, Vs=+2.7V, V_{CM}=+1.35V, V_O=+1.35V, T_A=25°C.

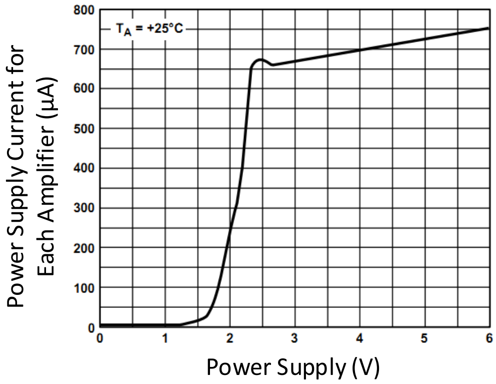
Parameter	Symbol	Condition	Min	Typ	Max	Unit
Input Characteristics						
Input Offset Voltage	V_{OS}			1	5	μV
		-40°C ≤ T_A ≤ +125°C			10	
Input Bias Current	I_B			10	50	pA
		-40°C ≤ T_A ≤ +125°C			4	nA
Input Offset Current	I_{OS}	-40°C ≤ T_A ≤ +125°C		150	400	pA
Input Voltage			0		2.7	V
Common-mode Rejection Ratio	CMRR	V_{CM} = 0V to 5V	115	120		dB
		-40°C ≤ T_A ≤ +125°C	110	120		
Large-signal Gain	A_{VO}	R_L= 10kΩ, V_O= 0.3V to 2.4V	110	130		dB
		-40°C ≤ T_A ≤ +125°C	105	130		
Input Offset Voltage Drift	$\Delta V_{OS}/\Delta T_A$	-40°C ≤ T_A ≤ +125°C		0.04	0.05	μV/°C
Output Characteristics						
High-level Output Voltage	V_{OH}	R_L = 100kΩ to GND	2.685	2.697		V
		-40°C ≤ T_A ≤ +125°C	2.685	2.696		
		R_L = 10kΩ to GND	2.67	2.68		V
		-40°C ≤ T_A ≤ +125°C	2.67	2.675		
Low-level Output Voltage	V_{OL}	R_L = 100kΩ to +Vs		1	10	mV
		-40°C ≤ T_A ≤ +125°C		2	10	
		R_L = 10kΩ to +Vs		10	20	mV
		-40°C ≤ T_A ≤ +125°C		15	20	
Short-circuit Current	I_{SC}		20	25		mA
		-40°C ≤ T_A ≤ +125°C		20		
Power Supply						
Power Supply Rejection Ratio	PSRR	Vs =1.8V to 5.5V, -40°C ≤ T_A ≤ +125°C	110	120		dB
Quiescent Current/Amplifier	I_Q	V_O = 0		750	900	μA
		-40°C ≤ T_A ≤ +125°C		950	1000	

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Dynamic Characteristics						
Gain Bandwidth Product	GBP	A_V = +100		2		MHz
Slew Rate	SR	A_V = +1, RL = 10kΩ		0.4		V/µs
Overload Recovery Time				0.05		ms
Noise Characteristics						
Voltage Noise	$e_{n\ P\text{-}P}$	0.1Hz to 10Hz		1.6		$\mu V_{p\text{-}p}$
Voltage Noise Density	e_n	f = 1kHz		75		$nV/\sqrt{Hz}$
Current Noise Density	i_n	f = 10Hz		2		$fA/\sqrt{Hz}$

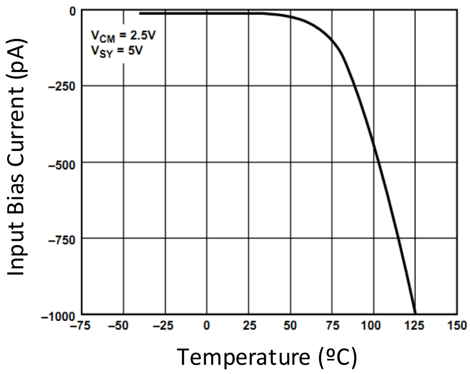
TYPICAL CHARACTERISTIC CURVES



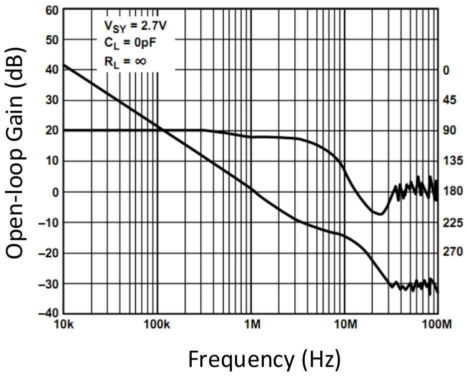
Output Voltage VS. Load Current at 2.7V



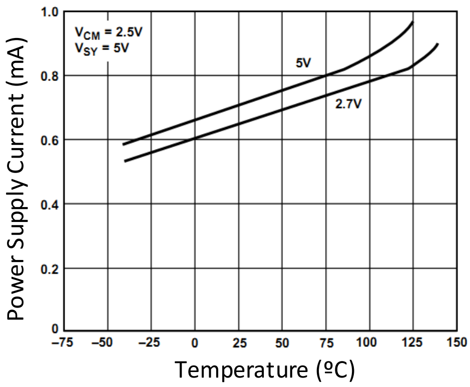
Power Supply Current for Each Amplifier VS. Power Supply



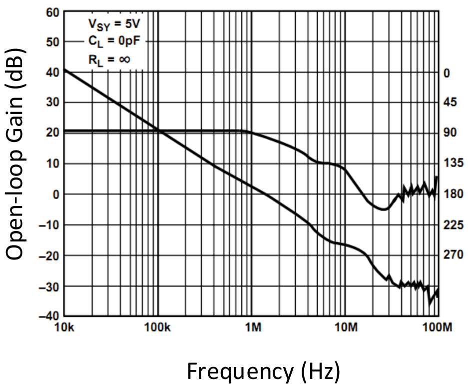
Input Bias Current VS. Temperature



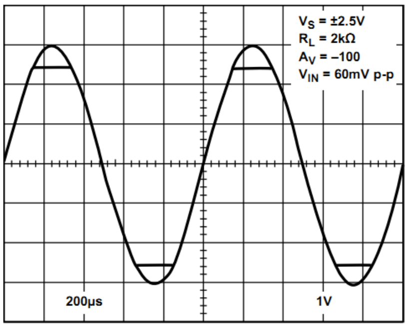
Open-loop Gain VS. Frequency at 2.7V



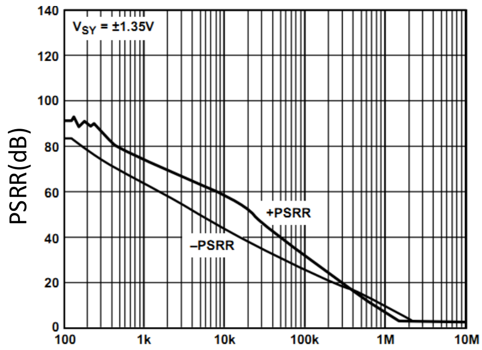
Power Supply Current VS. Temperature



Open-loop Gain VS. Frequency at 5V

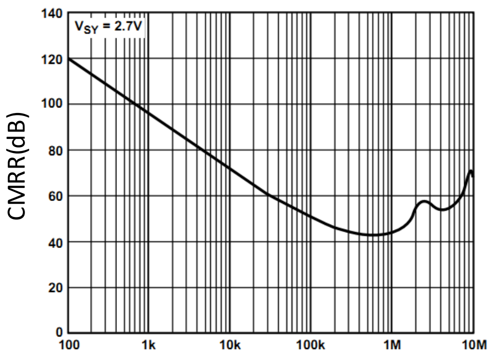


No Phase Reversal



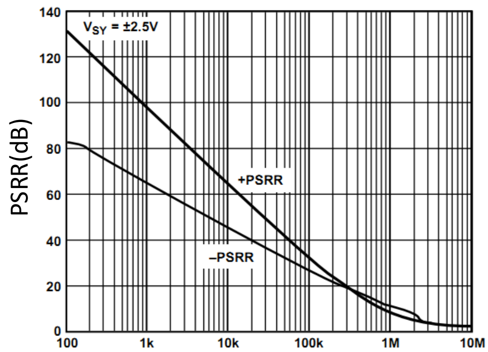
Frequency (Hz)

PSRR VS. Frequency at ±1.35V



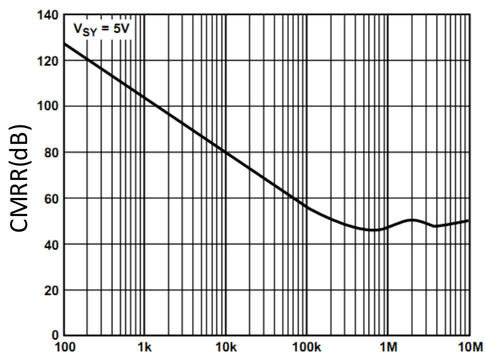
Frequency (Hz)

CMRR VS. Frequency at 2.7V



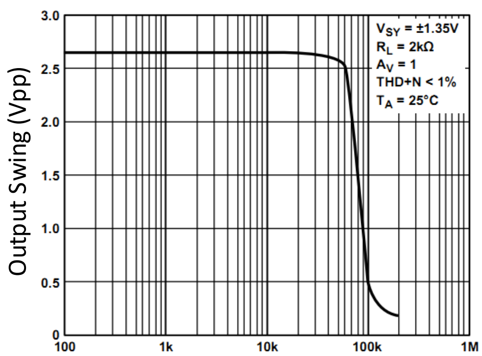
Frequency (Hz)

PSRR VS. Frequency at ±2.5V



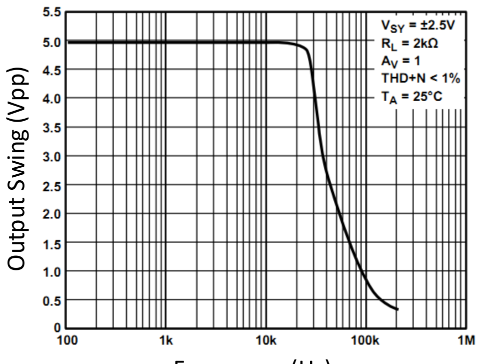
Frequency (Hz)

CMRR VS. Frequency at 5V

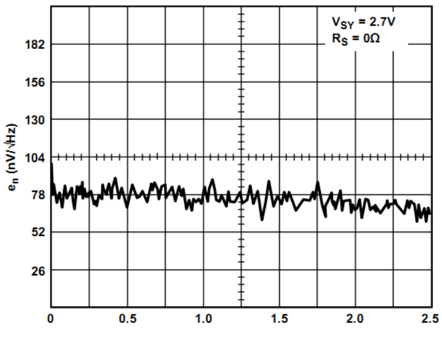


Frequency (Hz)

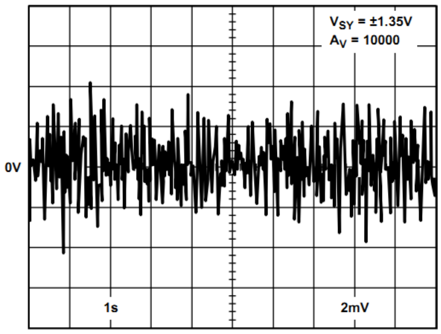
Maximum Output Swing VS. Frequency at 2.7V



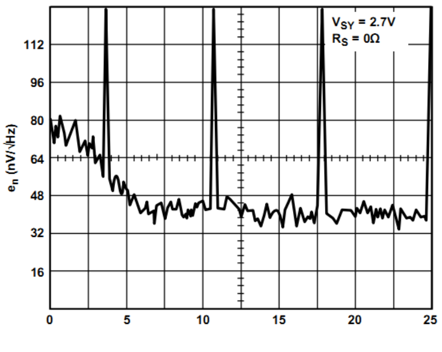
Maximum Output Swing VS. Frequency at 5V



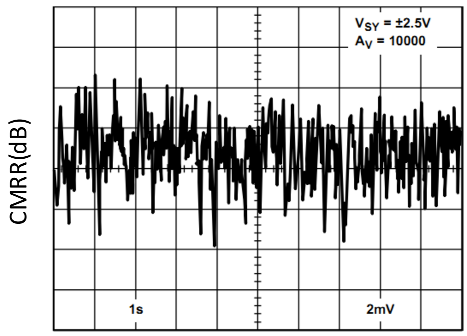
0Hz to 2.5kHz Voltage Noise Density at 2.7V



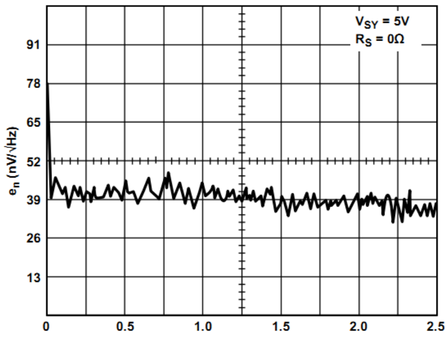
0.1Hz to 10Hz Noise at 2.7V



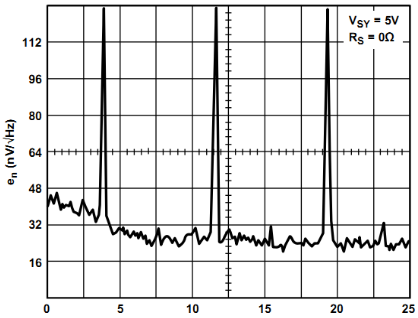
0Hz to 2.5kHz Voltage Noise Density at 2.7V



0.1Hz to 10Hz Noise at 5V

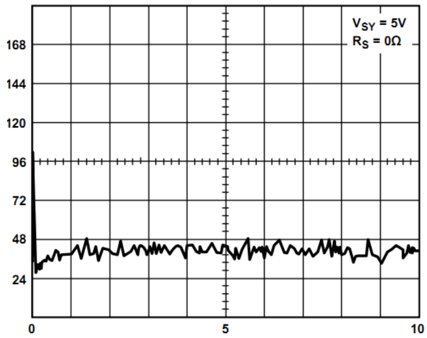


0Hz to 2.5kHz Voltage Noise Density at 5V



Frequency (kHz)

0Hz to 2.5kHz Voltage Noise Density at 5V



Frequency (Hz)

0Hz to 10Hz Voltage Noise Density at 5V

TYPICAL APPLICATIONS

5V High-precision Strain Gauge Circuit

The ultra-low input offset voltage makes the MS855x ideal for high-precision and high-gain applications, such as electronic weigh or strain gauge. The figure 1 shows the measurement system for a strain gauge with single power supply and high precision.

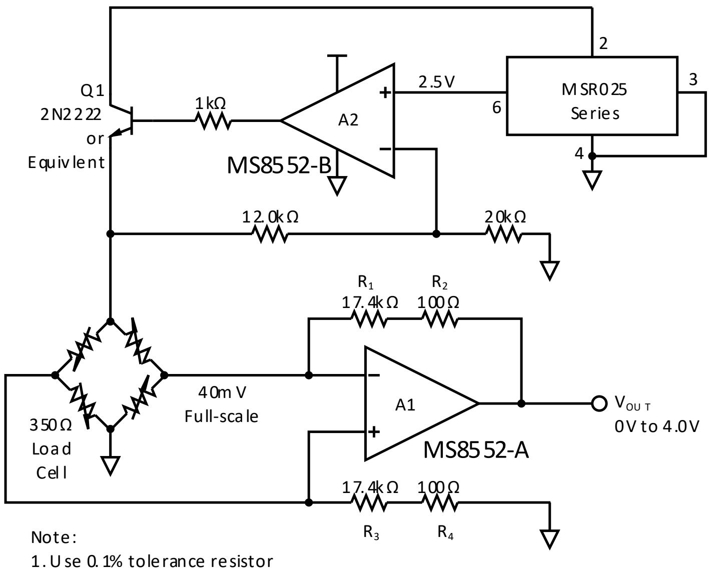


Figure 1. 5V High-precision Strain Gauge Circuit

3V Instrumentation Amplifier

The MS855X is the ideal selection for single power supply instrumentation amplifier due to the features of high CMRR, high open-loop gain and low to 3V operating voltage. The CMRR is more than 120dB. In Figure 2, the gain of the differential amplifier is:

$$V_{OUT}=V1\left(\frac{R_4}{R_3+R_4}\right)\left(1+\frac{R_1}{R_2}\right)-V2\left(\frac{R_2}{R_1}\right)$$

In the ideal differential amplifier, the resistor ratio is set as follows:

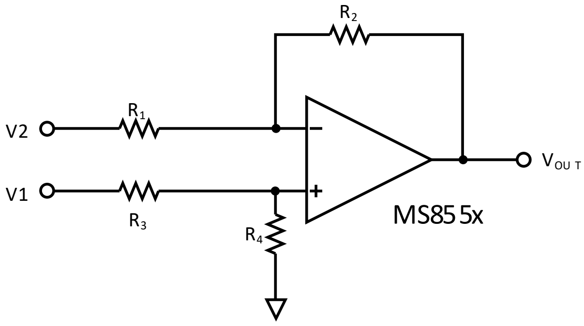
$$A_V=\frac{R_4}{R_3}=\frac{R_2}{R_1}$$

System output voltage is set as follows:

$$V_{OUT}=A_V(V1-V2)$$

Because of resistance accuracy mismatch, the actual CMRR in figure 2 is as follows:

$$CMRR=\frac{R_1R_4+2R_2R_4+R_2R_3}{2R_1R_4-2R_2R_3}$$

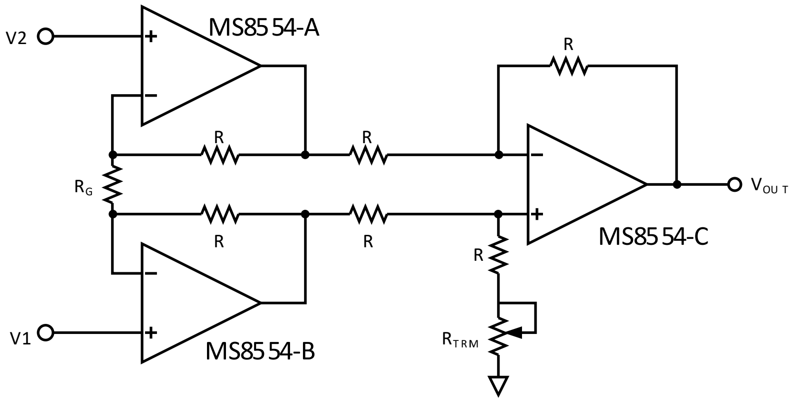


$$IF \frac{R_4}{R_3} = \frac{R_2}{R_1}, THEN\ V_{OUT} = \frac{R_2}{R_1} \times (V1 - V2)$$

Figure 2. Differential Amplifier Circuit with the MS855x

The three-amplifier instrumentation amplifier circuit is shown in Figure 3. If four resistances are same, the output voltage of differential amplifier is unity gain. If the resistor accuracy is δ, the CMRR of instrumentation amplifier in the worst-case is: $CMRR_{MIN}=1/2δ$。

If using 1%-accuracy resistor, CMRR in the worst-case system is 0.02 or 34dB. Therefore, high-precision resistors and an adjustable resistor are used to achieve high CMRR. The value of adjustable resistor should be equal to the value of R multiplied by accuracy. For example, using 10kΩ resistor with 1% accuracy needs to be in series with a 100Ω adjustable resistor.



$$V_{OUT} = 1 + \frac{2R}{R_G}(V1 - V2)$$

Figure 3. Discrete Instrumentation Amplifier Circuit

High-precision Thermocouple Amplifier

Figure 4 shows K-type thermocouple amplifier circuit using cold junction compensation. Using 5V power supply, accuracy of the MS855x can be up to 0.02°C ranging from 0°C to 500°C.

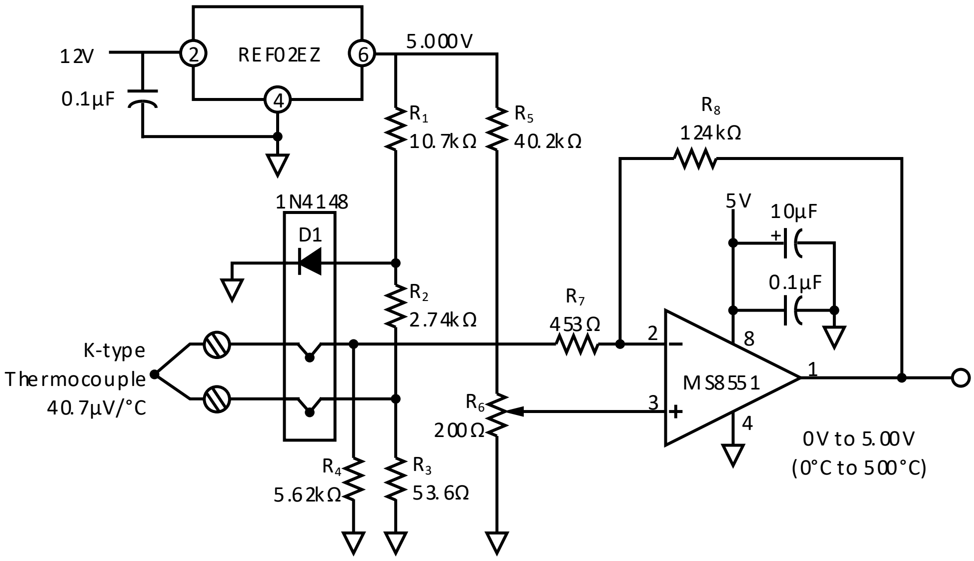


Figure 4. High-precision K-type Thermocouple Amplifier with Cold Junction Compensation

High-precision Current Meter

The MS855x is ideal amplifier for high-precision current measurement, due to the features of low input bias current and ultra-low offset voltage at single power supply.

Figure 5 shows the circuit for monitoring the current source. The output voltage is as follows:

$$V_{OUT}=R_2\times\frac{R_{SENSE}}{R_1}\times I_L$$

Figure 6 shows the circuit for monitoring the current sink. The output voltage is as follows:

$$V_{OUT}=(V+)-\left(\frac{R_2}{R_1}\times R_{SENSE}\times I_L\right)$$

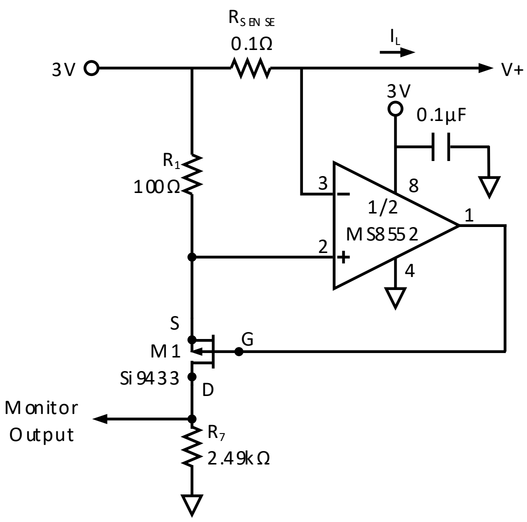


Figure 5. Current Source Monitor Circuit

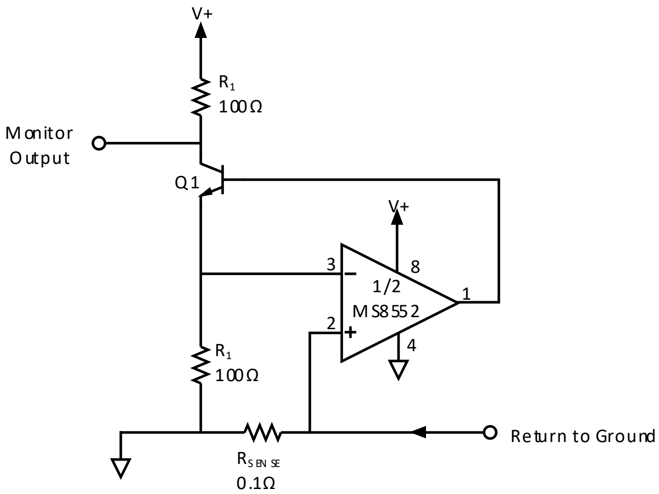


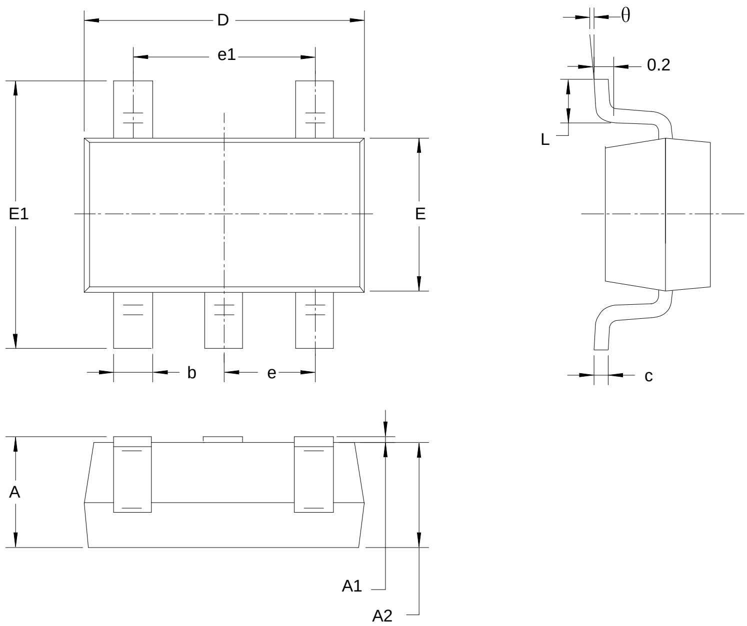
Figure 6. Current Sink Monitor Circuit

High-precision Voltage Comparator

The MS855x can be used as a high-precision voltage comparator in open-loop condition. The offset voltage of the MS855x is less than 50μV in this condition.

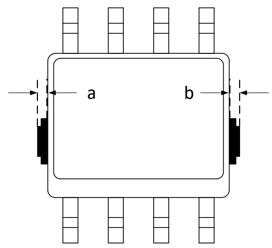
PACKAGE OUTLINE DIMENSIONS

SOT23-5



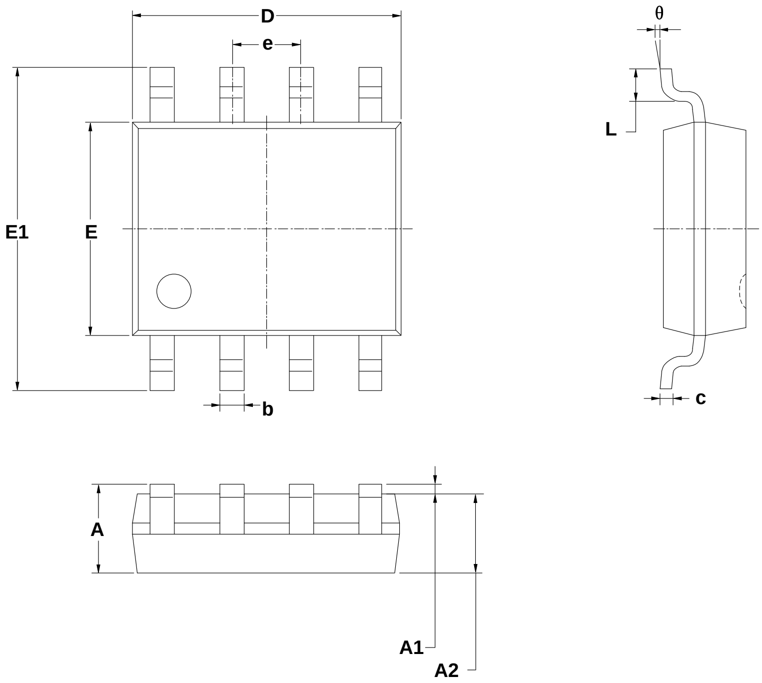
Note: In addition to the package size, a, b are allowed to have the maximum size of 0.15mm for waste glue simultaneously.

The diagram is as follows: taking SOP8 package as an example.

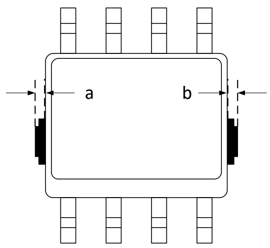


Symbol	Dimensions in Millimeters		Dimensions in Inches	
	Min	Max	Min	Max
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950 BSC		0.037 BSC	
e1	1.900 BSC		0.075 BSC	
L	0.300	0.600	0.012	0.024
θ	0º	8 º	0 º	8 º

SOP8

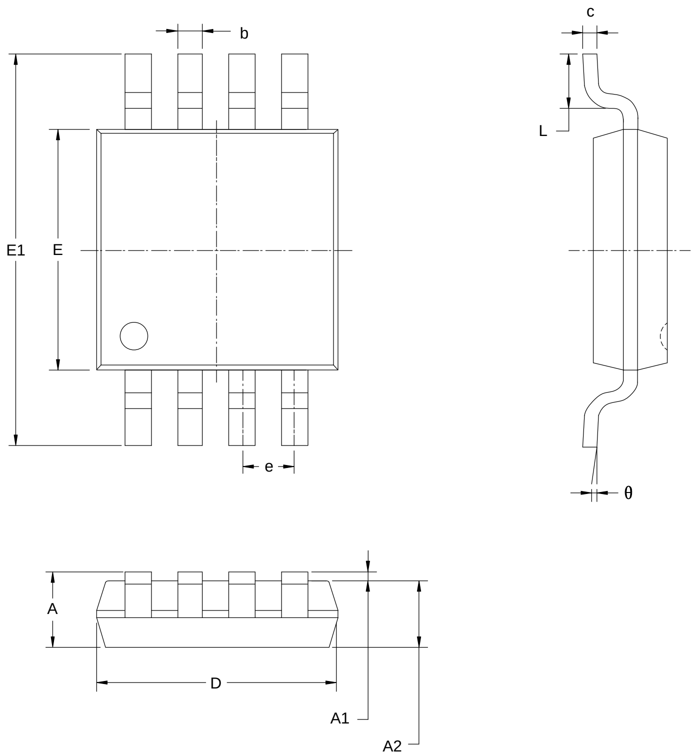


Note: In addition to the package size, a, b are allowed to have the maximum size of 0.15mm for waste glue simultaneously.



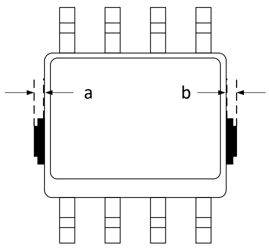
Symbol	Dimensions in Millimeters		Dimensions in Inches	
	Min	Max	Min	Max
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.006	0.010
D	4.700	5.100	0.185	0.200
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.27 BSC		0.050 BSC	
L	0.400	1.270	0.016	0.050
θ	0 º	8 º	0 º	8 º

MSOP8



Note: In addition to the package size, a, b are allowed to have the maximum size of 0.15mm for waste glue simultaneously.

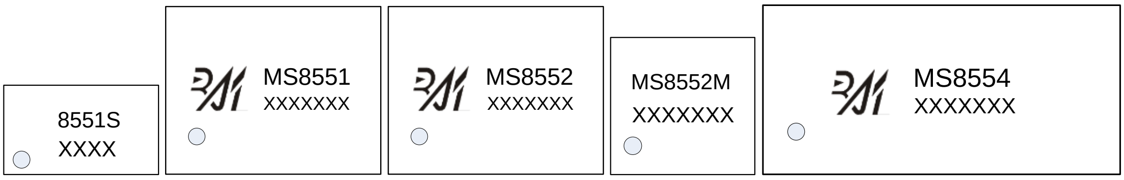
The diagram is as follows: taking SOP8 package as an example.



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	2.900	3.100	0.114	0.122
E1	4.750	5.050	0.187	0.199
e	0.650BSC		0.026BSC	
L	0.400	0.800	0.016	0.031
θ	0º	6º	0º	6º

MARKING and PACKAGING SPECIFICATIONS

1. Marking Drawing Description



Product Name: 8551S, MS8551, MS8552, MS8552M, MS8554

Product Code: XXXX, XXXXXXX

2. Marking Drawing Demand

Laser printing, contents in the middle, font type Arial.

3. Packaging Specifications

Device	Package	Piece/Reel	Reel/Box	Piece /Box	Box/Carton	Piece/Carton
MS8551S	SOT23-5	3000	10	30000	4	120000
MS8551	SOP8	2500	1	2500	8	20000
MS8552	SOP8	4000	1	4000	8	32000
MS8552M	MSOP8	3000	1	3000	8	24000
MS8554	SOP14	2500	1	2500	8	20000

STATEMENT

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- The process of improving product is endless. And our company would sincerely provide more excellent product for customer.

MOS CIRCUIT OPERATION PRECAUTIONS

Static electricity can be generated in many places. The following precautions can be taken to effectively prevent the damage of MOS circuit caused by electrostatic discharge:

1. The operator shall ground through the anti-static wristband.
2. The equipment shell must be grounded.
3. The tools used in the assembly process must be grounded.
4. Must use conductor packaging or anti-static materials packaging or transportation.

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