

# 1.1MHz, Precision, Rail-to-Rail I/O CMOS Operational Amplifier

## FEATURES

- **HIGH GAIN BANDWIDTH:1.1MHz**
- **RAIL-TO-RAIL INPUT AND OUTPUT**  
**±4.5mV Max Vos**
- **INPUT VOLTAGE RANGE: -0.1V to +5.6V**  
**with Vs = 5.5V**
- **SUPPLY RANGE: +2.5V to +5.5V**
- **SPECIFIED UP TO +125°C**
- **Micro SIZE PACKAGES: SOP8**

## APPLICATIONS

- **SENSORS**
- **PHOTODIODE AMPLIFICATION**
- **ACTIVE FILTERS**
- **TEST EQUIPMENT**
- **DRIVING A/D CONVERTERS**

## DESCRIPTION

The RS358A products offer low voltage operation and rail-to-rail input and output, as well as excellent speed/power consumption ratio, providing an excellent bandwidth (1.1MHz) and slew rate of 0.5V/us. The op-amps are unity gain stable and feature an ultra-low input bias current.

The RS358A has lower offset, which is guaranteed not upper than ±4.5mV at 25°C with Vs = 5V, V<sub>CM</sub> = Vs/2.

The devices are ideal for sensor interfaces, active filters and portable applications. The RS358A families of operational amplifiers are specified at the full temperature range of -40°C to +125°C under single or dual power supplies of 2.5V to 5.5V.

**Device Information (1)**

PART NUMBER	PACKAGE	BODY SIZE(NOM)
RS358A	SOP8	4.90mm×3.90mm
	MSOP8	3.00mm×3.00mm
	TSSOP8	3.00mm×4.40mm

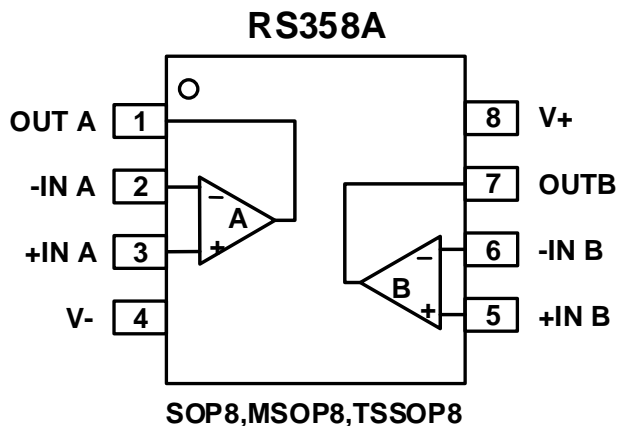
(A) For all available packages, see the orderable addendum at the end of the data sheet.

## Revision History

Note: Page numbers for previous revisions may differ from page numbers in the current version.

VERSION	Change Date	Change Item
A.1	2020/03/23	Initial version completed
A.2	2021/11/10	Add "Figure 3. Functional Block Diagram" on Page 11 Update Package Qty on Page 2@RevA.1
A.2.1	2024/03/05	Modify packaging naming

## Pin Configuration and Functions (Top View)



### Pin Description

NAME	PIN	I/O	DESCRIPTION
	SOP8/MSOP8/TSSOP8		
-INA	2	I	Inverting input, channel A
+INA	3	I	Noninverting input, channel A
-INB	6	I	Inverting input, channel B
+INB	5	I	Noninverting input, channel B
OUTA	1	O	Output, channel A
OUTB	7	O	Output, channel B
V-	4	-	Negative (lowest) power supply
V+	8	-	Positive (highest) power supply

## SPECIFICATIONS

### Absolute Maximum Ratings

Over operating free-air temperature range (unless otherwise noted) <sup>(1)</sup>

		MIN	MAX	UNIT
Voltage	Supply, $V_s=(V+) - (V-)$		7	V
	Signal input pin <sup>(2)</sup>	(V-)-0.5	(V+) +0.5	
	Signal output pin <sup>(3)</sup>	(V-)-0.5	(V+) +0.5	
Current	Signal input pin <sup>(2)</sup>	-10	10	mA
	Signal output pin <sup>(3)</sup>	-140	140	mA
	Output short-circuit <sup>(4)</sup>	Continuous		
Temperature	Operating range, $T_A$	-40	125	°C
	Junction, $T_J$		150	
	Storage, $T_{stg}$	-65	150	

(1) Stresses above these ratings may cause permanent damage. Exposure to absolute maximum conditions for extended periods may degrade device reliability. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those specified is not implied.

(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.

(3) Output terminals are diode-clamped to the power-supply rails. Output signals that can swing more than 0.5V beyond the supply rails should be current-limited to  $\pm 140$ mA or less.

(4) Short-circuit to ground, one amplifier per package.

### ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human-body model (HBM)	$\pm 3000$	V
		Machine Model (MM)	$\pm 200$	

### Recommended Operating Conditions

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

		MIN	NOM	MAX	UNIT
Supply voltage , $V_s= (V+) - (V-)$	Single-supply	2.5		5.5	V
	Dual-supply	$\pm 1.25$		$\pm 2.75$	

### Thermal Information: RS358A

THERMAL METRIC		RS358A			UNIT
		8PINS			
		SOP8	MSOP8	TSSOP8	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	116	165	192	°C/W
$R_{\theta JC(top)}$	Junction-to-case(top) thermal resistance	60	53	64.3	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	56	87	105.3	°C/W
$\Psi_{JT}$	Junction-to-top characterization parameter	12.8	4.9	7.6	°C/W
$\Psi_{JB}$	Junction-to-board characterization parameter	98.3	85	105.5	°C/W
$R_{\theta JC(bot)}$	Junction-to-case(bottom) thermal resistance	N/A	N/A	22.7	°C/W

**PACKAGE/ORDERING INFORMATION**

Orderable Device	Package Type	Pin	Channel	Op Temp(°C)	Device Marking <sup>(1)</sup>	Package Qty
RS358AXK	SOP8	8	2	-40°C~125°C	RS358A	Tape and Reel,4000
RS358AXM	MSOP8	8	2	-40°C~125°C	RS358A	Tape and Reel,4000
RS358AXQ	TSSOP8	8	2	-40°C~125°C	RS358A	Tape and Reel,4000

## NOTE:

(1) There may be additional marking, which relates to the lot trace code information (data code and vendor code), the logo or the environmental category on the device.

## ELECTRICAL CHARACTERISTICS

(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.)

PARAMETER		CONDITIONS	$T_J$	RS358A			
				MIN	TYP	MAX	UNIT
<b>POWER SUPPLY</b>							
$V_S$	Operating Voltage Range		$25^\circ\text{C}$	2.5		5.5	V
$I_Q$	Quiescent Current/Amplifier		$25^\circ\text{C}$		60	110	$\mu\text{A}$
PSRR	Power-Supply Rejection Ratio	$V_S = 2.5\text{V to } 5.5\text{V}$ , $V_{CM} = (V_-) + 0.5\text{V}$	$25^\circ\text{C}$	74	90		dB
			$-40^\circ\text{C to } 125^\circ\text{C}$	65			
<b>INPUT</b>							
$V_{OS}$	Input Offset Voltage	$V_{CM} = 0\text{V to } 3.5\text{V}$	$25^\circ\text{C}$	-4.5	$\pm 0.8$	4.5	mV
$V_{OS} T_C$	Input Offset Voltage Average Drift		$-40^\circ\text{C to } 125^\circ\text{C}$		$\pm 2$		$\mu\text{V}/^\circ\text{C}$
$I_B$	Input Bias Current		$25^\circ\text{C}$		$\pm 10$	$\pm 100$	pA
$I_{OS}$	Input Offset Current		$25^\circ\text{C}$		$\pm 1$	$\pm 10$	pA
$V_{CM}$	Common-Mode Voltage Range	$V_S = 5.5\text{V}$	$25^\circ\text{C}$	-0.1		5.6	V
CMRR	Common-Mode Rejection Ratio	$V_S = 5.5\text{V}$ $V_{CM} = -0.1\text{V to } 4\text{V}$	$25^\circ\text{C}$	74	90		dB
			$-40^\circ\text{C to } 125^\circ\text{C}$	68			
			$25^\circ\text{C}$	63	80		
			$-40^\circ\text{C to } 125^\circ\text{C}$	57			
<b>OUTPUT</b>							
$A_{OL}$	Open-Loop Voltage Gain	$R_L = 2\text{k}\Omega$ $V_O = 0.15\text{V to } 4.85\text{V}$	$25^\circ\text{C}$	85	105		dB
			$-40^\circ\text{C to } 125^\circ\text{C}$	80			
			$25^\circ\text{C}$	88	110		
			$-40^\circ\text{C to } 125^\circ\text{C}$	83			
	Output Swing From Rail	$R_L = 2\text{k}\Omega$ $R_L = 10\text{k}\Omega$	$25^\circ\text{C}$		25		mV
					8		
$I_{OUT}$	Output Current Source		$25^\circ\text{C}$		130		mA
<b>FREQUENCY RESPONSE</b>							
SR	Slew Rate		$25^\circ\text{C}$		0.5		V/ $\mu\text{s}$
GBP	Gain-Bandwidth Product		$25^\circ\text{C}$		1.1		MHz
PM	Phase Margin		$25^\circ\text{C}$		64		$^\circ$
$t_s$	Setting Time, 0.1%				1.3		$\mu\text{s}$
	Overload Recovery Time	$V_{IN} \cdot \text{Gain} \geq V_S$			2.3		$\mu\text{s}$
<b>NOISE</b>							
$e_n$	Input Voltage Noise Density	$f = 1\text{KHz}$	$25^\circ\text{C}$		22		$\text{nV}/\sqrt{\text{Hz}}$
		$f = 10\text{KHz}$	$25^\circ\text{C}$		20		$\text{nV}/\sqrt{\text{Hz}}$

## TYPICAL CHARACTERISTICS

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

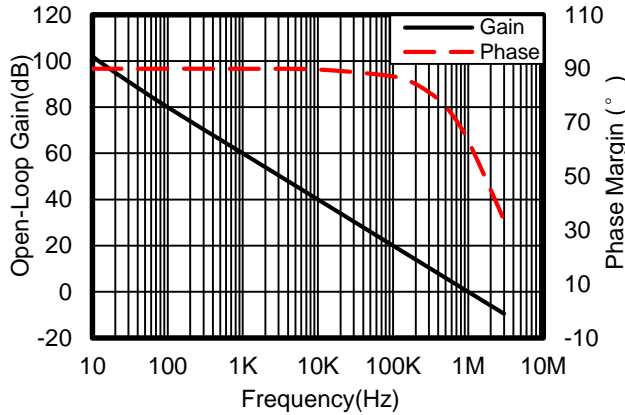


Figure 1. Open-Loop Gain And Phase vs Frequency

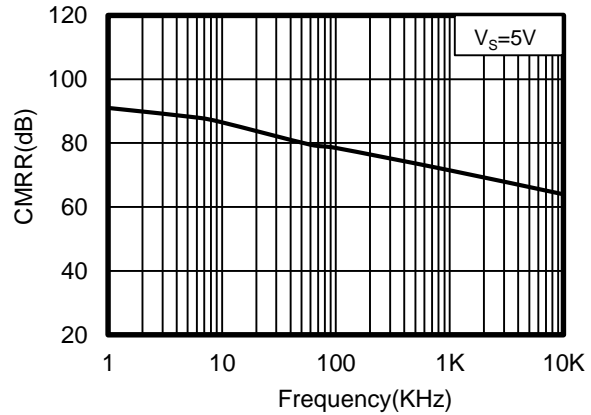


Figure 2. Common-Mode Rejection Ratio vs Frequency

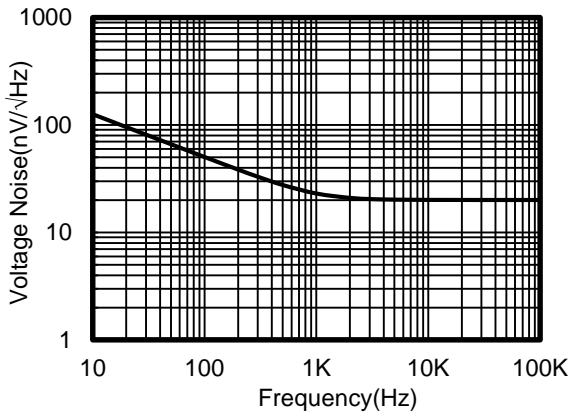


Figure 3. Input Voltage Noise Spectral Density vs Frequency

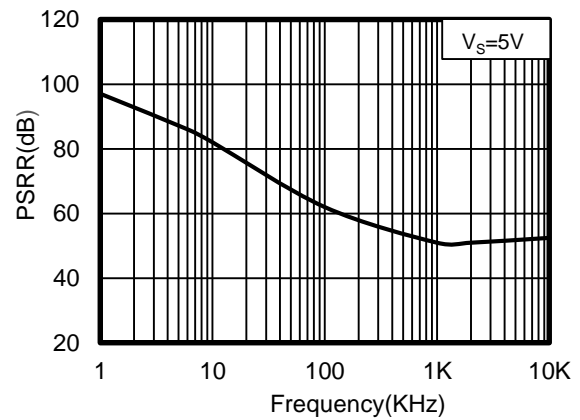


Figure 4. Power-Supply Rejection Ratio vs Frequency

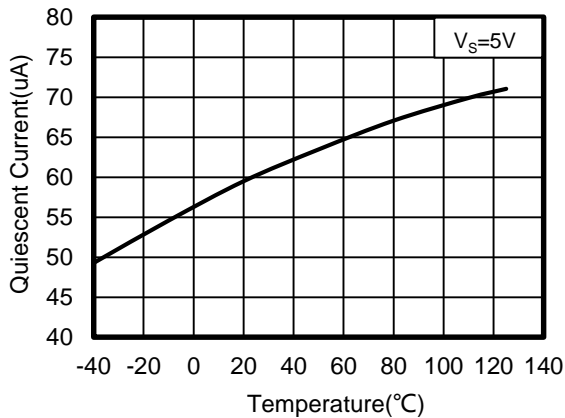


Figure 5. Quiescent Current vs Temperature

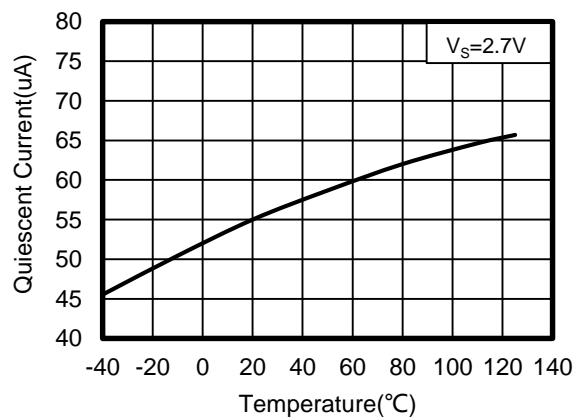


Figure 6. Quiescent Current vs Temperature

## TYPICAL CHARACTERISTICS

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

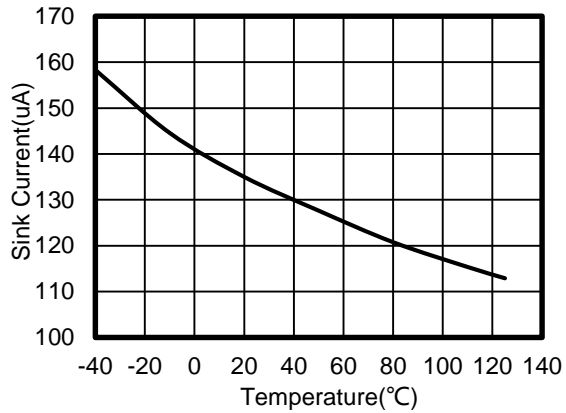


Figure 7. Sink Current vs Temperature

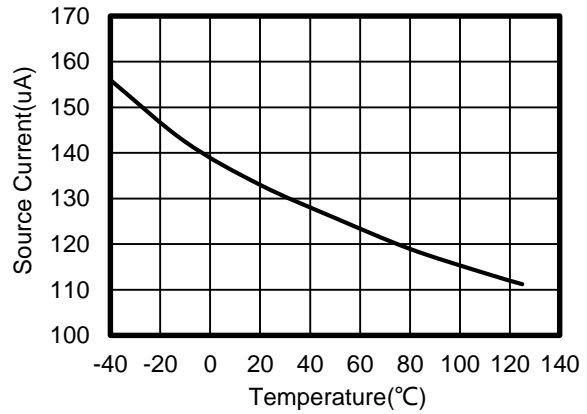


Figure 8. Source Current vs Temperature

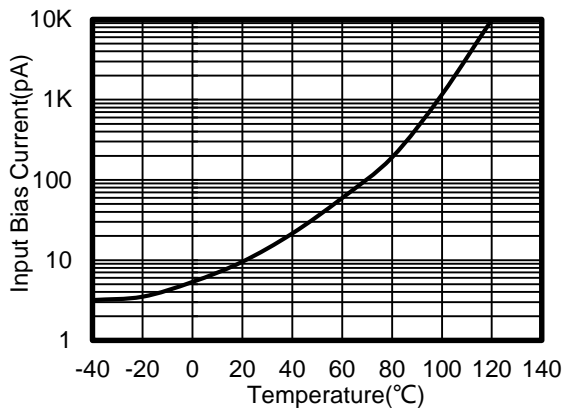


Figure 9. Input Bias Current vs Temperature

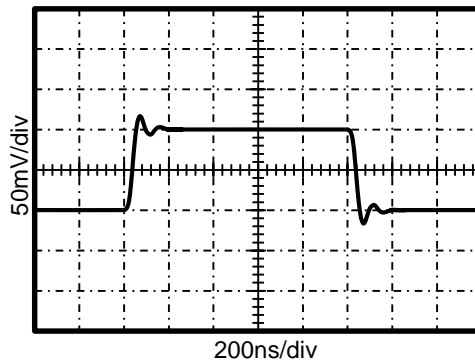


Figure 10. Small-Signal Step Response

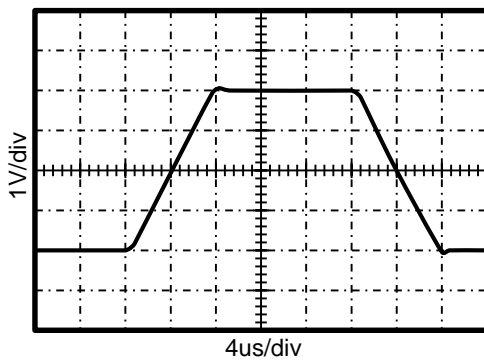


Figure 11. Large-Signal Step Response

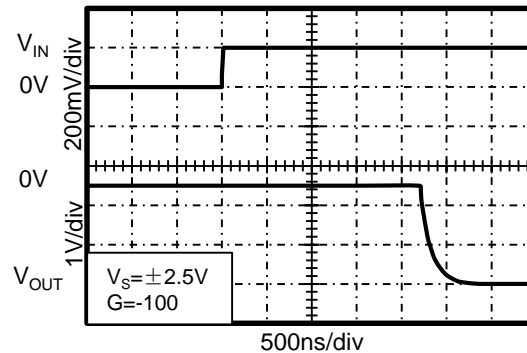


Figure 12. Positive Overvoltage Recovery



## TYPICAL CHARACTERISTICS

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

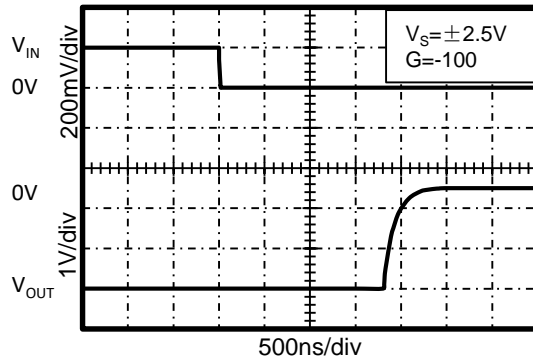


Figure 13. Negative Overvoltage Recovery

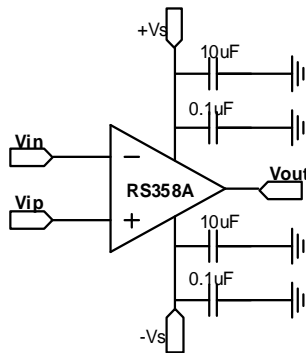
## APPLICATION NOTES

The RS358A is high precision, rail-to-rail operational amplifiers that can be run from a single-supply voltage 2.5V to 5.5V ( $\pm 1.25V$  to  $\pm 2.75V$ ). Supply voltages higher than 7V (absolute maximum) can permanently damage the amplifier. Rail-to-rail input and output swing significantly increases dynamic range, especially in low-supply applications. Good layout practice mandates use of a 0.1 $\mu F$  capacitor placed closely across the supply pins.

## LAYOUT GUIDELINS

Attention to good layout practices is 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 0.1 $\mu F$  capacitor closely across the supply pins.

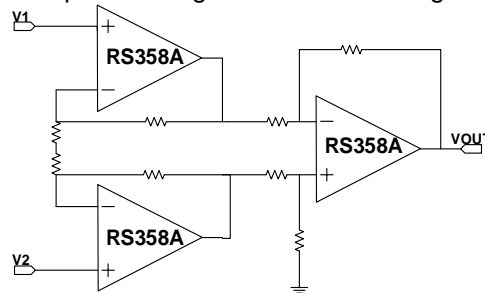
These guidelines should be applied throughout the analog circuit to improve performance and provide benefits such as reducing the EMI susceptibility.



**Figure 14. Amplifier with Bypass Capacitors**

## INSTRUMENTATION AMPLIFIER

In the three-op amp, instrumentation amplifier configuration shown in Figure 15.



**Figure 15. Amplifier instrumentation amplifier**

Overview

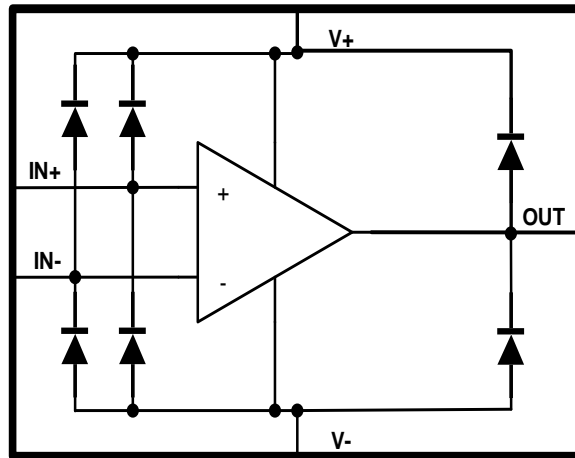
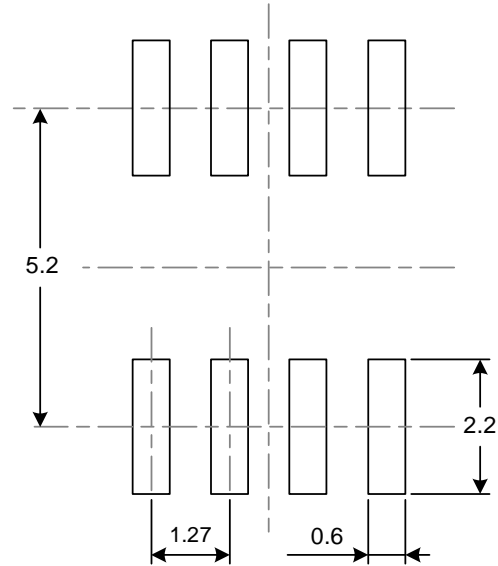
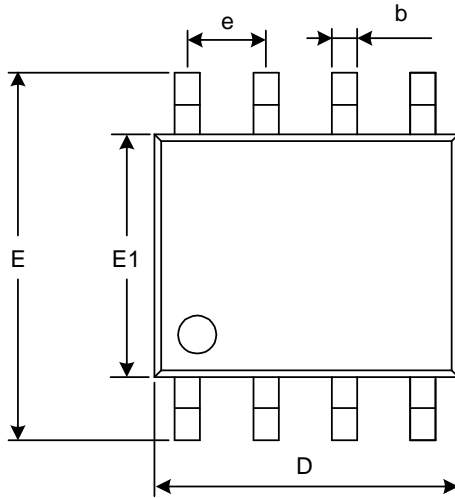


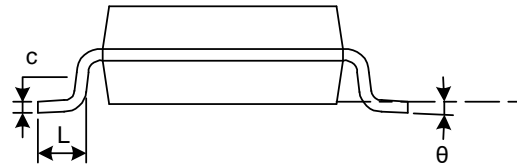
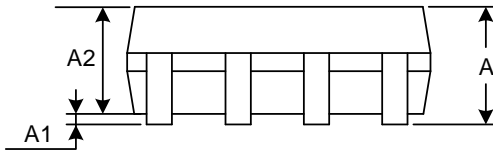
Figure 16. Functional Block Diagram

# PACKAGE OUTLINE DIMENSIONS

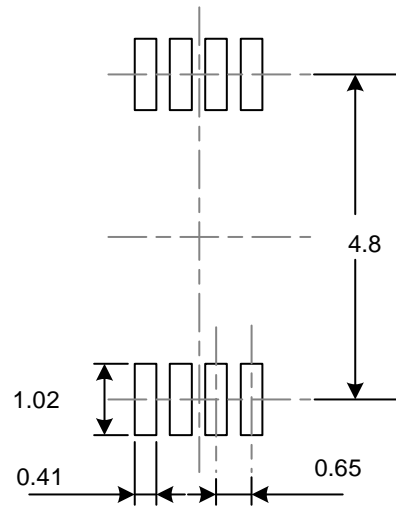
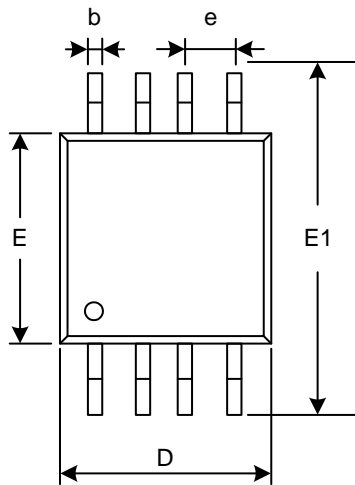
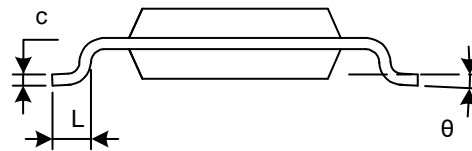
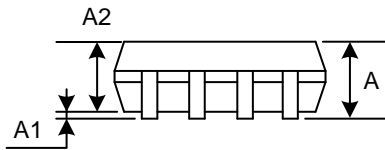
## SOP8



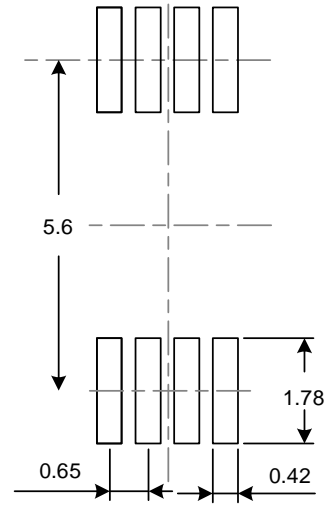
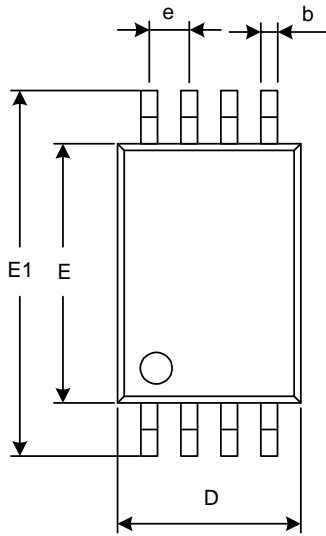
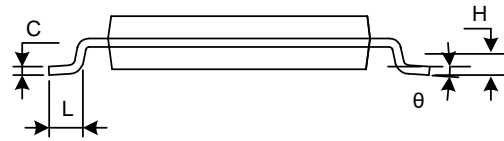
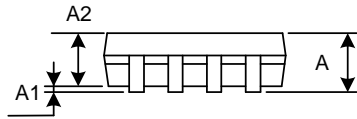
RECOMMENDED LAND PATTERN (Unit: mm)



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	0.007	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
$\theta$	0°	8°	0°	8°

**MSOP8**

**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
$\theta$	0°	6°	0°	6°

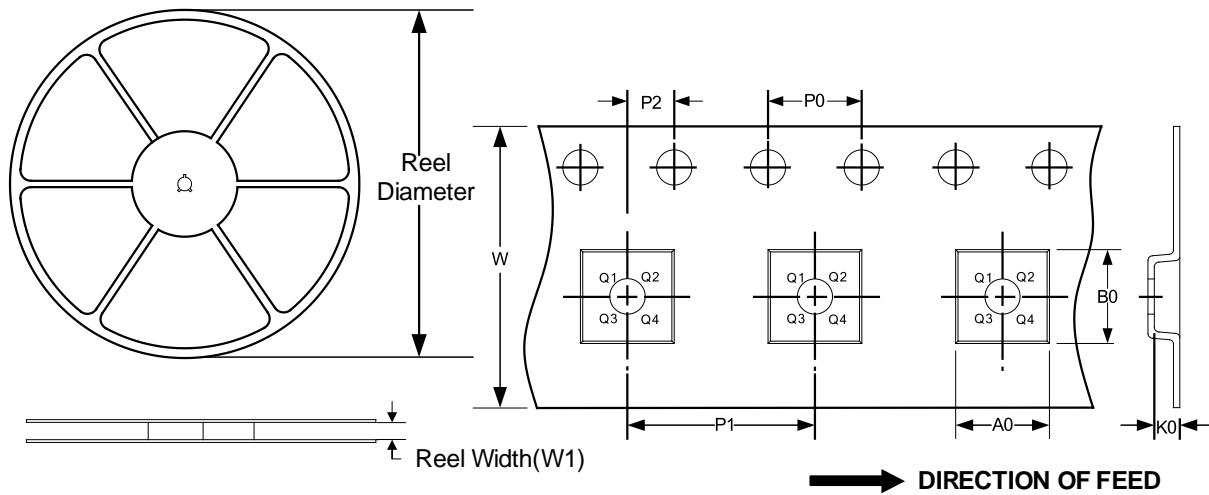
**TSSOP8**

**RECOMMENDED LAND PATTERN (Unit: mm)**


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A		1.200		0.047
A1	0.050	0.150	0.002	0.006
A2	0.800	1.050	0.031	0.041
b	0.190	0.300	0.007	0.012
c	0.090	0.200	0.004	0.008
D	2.900	3.100	0.114	0.122
E	4.300	4.500	0.169	0.177
E1	6.250	6.550	0.246	0.258
e	0.650(BSC)		0.026(BSC)	
L	0.500	0.700	0.020	0.028
H	0.25(TYP)		0.01(TYP)	
$\theta$	1°	7°	1°	7°

## TAPE AND REEL INFORMATION

### REEL DIMENSIONS

### TAPE DIMENSION



NOTE: The picture is only for reference. Please make the object as the standard.

### KEY PARAMETER LIST OF TAPE AND REEL

Package Type	Reel Diameter	Reel Width (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	P1 (mm)	P2 (mm)	W (mm)	Pin1 Quadrant
SOP8	13"	12.4	6.40	5.40	2.10	4.0	8.0	2.0	12.0	Q1
TSSOP8	13"	12.4	6.90	3.45	1.65	4.0	8.0	2.0	12.0	Q1
MSOP8	13"	12.4	5.20	3.30	1.50	4.0	8.0	2.0	12.0	Q1