



AS2333

1.8V, MICROPOWER CMOS ZERO-DRIFT OPERATIONAL AMPLIFIERS

Description

The AS2333 is dual CMOS operational amplifiers designed with chopping stabilization technique. This product can provide ultra-low input offset voltage (8µV typical) and near zero-drift over time and temperature. This technique also eliminates 1/f noise, and the cross over distortion presented in most rail to rail input operational amplifiers. The high-precision, low quiescent current amplifier offers high-impedance inputs that have a common-mode range 100mV beyond the rails, and rail-to-rail output that swings within 50mV of the rails. Single or dual supplies as low as 1.8V (± 0.9 V) and up to 5.5V (± 2.75 V) can be used.

The device is optimized for low voltage single supply application, especially for low-power high precision applications.

The AS2333 is available in standard 8-pin SO-8, MSOP-8 and U-DFN3030-8 (Type E) packages, and is specified for operation from -40°C to +125°C.

Features

Low Input Offset Voltage: 8µV (typ)

Zero Drift: 0.02µV/°C (typ)

0.01Hz to 10Hz Noise: 1.1µVpp

Low Quiescent Current: 12µA per Amplifier

Supply Voltage: 1.8V to 5.5V

Rail-to-Rail Input and Output

Bandwidth 350kHz

Slew Rate 0.12V/µs (typ)

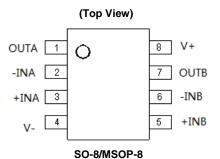
MSOP-8, SO-8 and U-DFN3030-8 (Type E) Packages

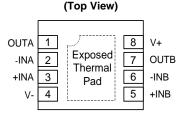
Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)

Halogen and Antimony Free. "Green" Device (Note 3)

 For automotive applications requiring specific change control (i.e. parts qualified to AEC-Q100/101/200, PPAP capable, and manufactured in IATF 16949 certified facilities), please contact us or your local Diodes representative. https://www.diodes.com/quality/product-definitions/

Pin Assignments





U-DFN3030-8 (Type E)

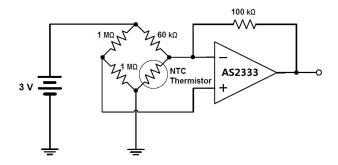
Applications

- Battery-Powered Instruments
- Handheld Test Equipment
- Medical Instrumentation
- Sensor Signal Conditioning
- Low Voltage Current Sensing

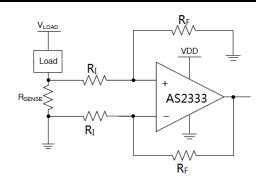
Notes:

- 1. No purposely added lead. Fully EU Directive 2002/95/EC (RoHS), 2011/65/EU (RoHS 2) & 2015/863/EU (RoHS 3) compliant.
- 2. See https://www.diodes.com/quality/lead-free/ for more information about Diodes Incorporated's definitions of Halogen- and Antimony-free, "Green" and Lead-free.
- 3. Halogen- and Antimony-free "Green" products are defined as those which contain <900ppm bromine, <900ppm chlorine (<1500ppm total Br + Cl) and <1000ppm antimony compounds.

Typical Application



Thermistor Measurement



Low-Side Current Monitor



Pin Descriptions

Pin Number	Pin Name	I/O	Description
3	+INA	I	Noninverting input, channel A
5	+INB	I	Noninverting input, channel B
2	-INA	1	Inverting input, channel A
6	-INB	1	Inverting input, channel B
1	OUTA	0	Output, channel A
7	OUTB	0	Output, channel B
8	V+	_	Positive Power Supply Recommend to place a minimum 0.1µF decoupling capacitor between V+ pin and GND as close as possible.
4	V-	_	Negative Power Supply Single power supply application, it is normally tied to ground. Split power supply application, a minimum 0.1µF decouple capacitor will be recommended to place between V- pin and GND as close as possible.

Absolute Maximum Ratings (Note 4) (@TA = +25°C, unless otherwise specified.)

Symbol	Parameter	Rating	g	Unit
Vs = V+ - V-	Supply Voltage Range	6.5		V
V-IN / V+IN	Signal Input Terminals (Note 5)	V 0.3V to V	+ + 0.3V	V
	Signal Input Terminals (Note 5)	-1 to +	1	mA
_	Output Short-Circuit (Note 6)	Continuo	ous	mA
Tstg	Storage Temperature	-65 to +1	150	°C
TJ	Maximum Junction Temperature	+150	+150	
TLEAD	Lead Temperature (Soldering, 10 Seconds)	+260		°C
		SO-8	139	°C/W
Reja	Junction-to-Ambient Thermal Resistance	MSOP-8	184	°C/W
		U-DFN3030-8 (Type E)	_	°C/W
		SO-8	25	°C/W
Rejc	Junction-to-Case Thermal Resistance	MSOP-8	18	°C/W
		U-DFN3030-8 (Type E)	_	°C/W
ESD HBM	Human Body Model ESD Protection	4		kV
ESD CDM	Charged-Device Model ESD Protection	1		kV

Notes:

- 4. Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Recommended Operating Conditions indicate conditions for which the device is intended to be functional, but specific performance is not guaranteed. For guaranteed specifications and the test conditions, see the Electrical Characteristics.
- 5. Input terminals are diode-clamped to the power-supply rails. Input signals that can swing more than 0.3V beyond the supply rails should be current limited to 10mA or less.
- 6. Short-circuit to ground.

Recommended Operating Conditions (@TA = +25°C, unless otherwise specified.)

Symbol	Parameter	Rating	Unit
V _S = V+ - V-	Supply Voltage Range	1.8 to 5.5	V
TA	Operating Ambient Temperature Range	-40 to +125	°C



Electrical Characteristics (@TA = +25°C, VS = 5.0V, RL = 10k Ω connected to VS / 2, VCM = VS / 2, and VOUT = VS / 2, unless otherwise specified.)

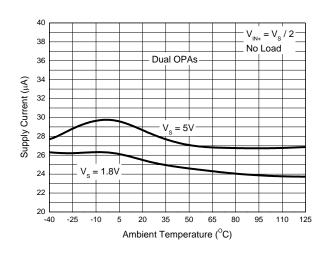
Symbol	Parameter	Conditions		Min	Тур	Max	Unit
Offset Voltage	Offset Voltage						
Vos	Input Offset Voltage	Vs = 5V		_	8	22	μV
A\//AT	Input Offset Voltage Drift (Note 7)	$T_A = -40^{\circ}C \text{ to } +85$	°C	_	0.02	0.1	μV/°C
ΔV _{OS} /ΔT	Input Onset Voltage Drift (Note 7)	$T_A = -40^{\circ}C \text{ to } +12$	5°C	_	_	0.2	μV/°C
PSRR	Power-Supply Rejection Ratio	V _S = 1.8V to 5.5V +125°C	$T_A = -40^{\circ}C$ to	_	1	5	μV/V
	Long-Term Stability	— (Note 7)			μV		
	Channel Separation, DC	_		_	0.1	_	μV/V
Input Bias Cur	rent						
lв	IB Input Bias Current			_	±70	±200	
IB	Input bias current	$T_A = -40^{\circ}C \text{ to } +12^{\circ}$	5°C	_	±400	_	pА
los	Input Offset Current	_		_	±140	±400	
Noise							
VN	Input Voltage Noise	f = 0.01Hz to $1Hz$		_	0.3	_	\/
۷N	Input voltage Noise	f = 0.1Hz to 10Hz		_	1.1	_	μVрр
I _N	Input Current Noise	f = 10Hz		_	100	_	fA/√Hz
Input Voltage							
V _{СМ}	Common-Mode Voltage Range	_		(V-) - 0.1	_	(V+) + 0.1	V
CMRR	Common-Mode Rejection Ratio	$(V-) - 0.1V < V_{CM} < (V+) + 0.1V,$ $T_A = -40^{\circ}C$ to $+125^{\circ}C$		106	120	_	dB
Input Capacita	ince					•	
	Differential	_		_	2	_	pF
	Common-Mode	_		_	4	_	pF
Open-Loop Ga	in					•	
AoL	Open-Loop Voltage Gain	$(V-) + 100 \text{mV} < V_O < (V+) - 100 \text{mV},$ $R_L = 10 \text{k}\Omega, T_A = -40^{\circ}\text{C to} + 125^{\circ}\text{C}$		106	130	_	dB
Frequency Res	sponse			•			
GBW	Gain-Bandwidth Product	C _L = 100pF		_	350	_	kHz
SR	Slew Rate	G = +1		_	0.12	_	V/µs
Output		•		•			
		Positive Rail	T _A = +25°C	_	30	50	
	Voltage Output Code of trans Ball	$R_L = 10k\Omega$	T _A = -40°C to +125°C	_	_	70	\/
_	Voltage Output Swing from Rail	Negative Rail	T _A = +25°C	_	10	50	mV
		$R_L = 10k\Omega$	T _A = -40°C to +125°C	_	_	70	
la a	Short Circuit Current	Source Current		_	5	_	mA
Isc	Short-Circuit Current	Sink Current		_	25	_	mA
	Open-Loop Output Impedance	f = 350kHz, I _O = 0A		_	2	_	kΩ
Power Supply							
Vs	Specified Voltage Range	_		1.8	_	5.5	V
1-	Quincoant Current per Amplifica	$I_0 = 0A$, $T_A = +25^\circ$	C	_	12	20	
Iq	Quiescent Current per Amplifier	$I_O = 0A$, $T_A = -40^\circ$	C to +125°C			28	μΑ
ton	Turn-On Time	Vs = 5V			100	_	μs

Note: 7. 300-hour life test at +150°C demonstrated randomly distributed variation of approximately $1\mu V$. This parameter guaranteed by design and characterization, not by testing.

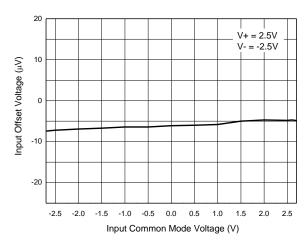


Typical Performance Characteristics

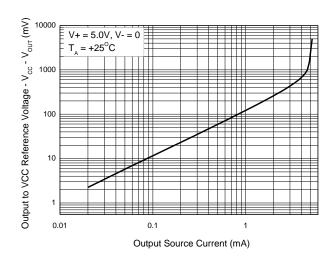
Supply Current vs. Temperature



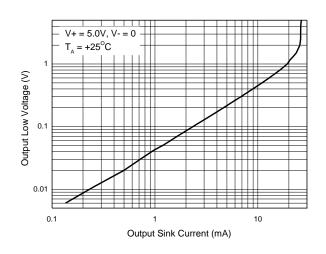
Input Offset Voltage vs. Input Common Mode Voltage



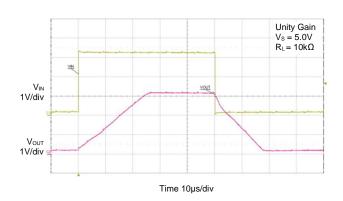
Output Characteristics-Sourcing Current



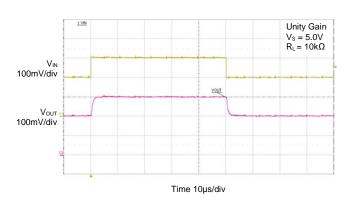
Output Characteristics-Sinking Current



Large Signal Response



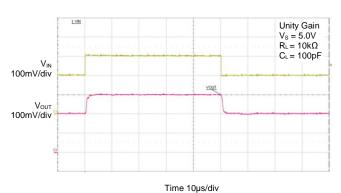
Small Signal Response



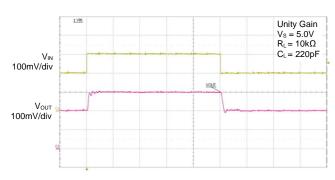


Typical Performance Characteristics (continued)

Small Signal Response

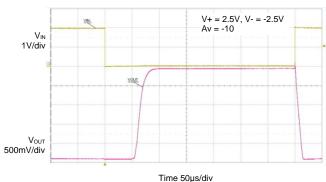


Small Signal Response

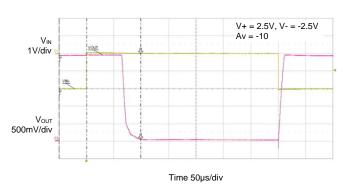


Time 10µs/div

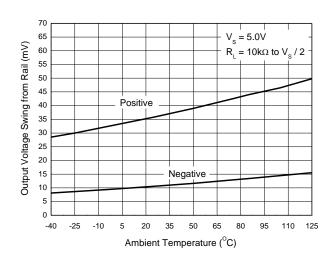
Negative Overvoltage Response



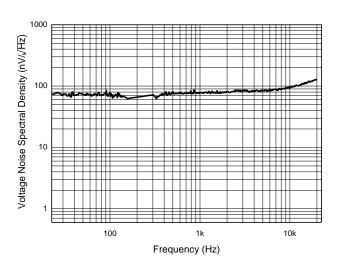
Positive Overvoltage Response



Output Voltage Swing from Rail



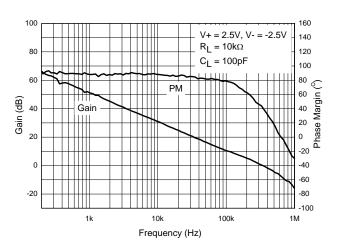
Voltage Noise Spectral Density



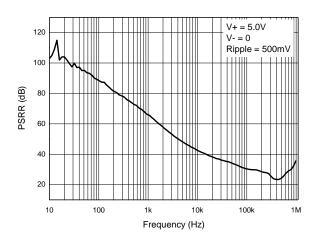


Typical Performance Characteristics (continued)

Frequency Response



Power Supply Rejection Ration vs. Frequency





Application Information

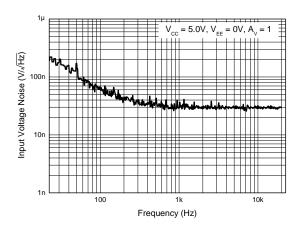
Overview

The AS2333 is low power, zero-drift, high precision, rail-to-rail input and output operational amplifier, which adopts chopper-stabilized function circuits to provide the advantage of minimizing input offset voltage and offset voltage drift over time and temperature. Its input common-mode voltage range extends 0.1V beyond the supply rails to allow for sensing near ground or system V_{DD}. The device operates from a single-supply voltage as low as 1.8V, is unity-gain stable, has no 1/f noise, has good PSRR and CMRR performance. These features make the part suitable for a wide range of general-purpose applications, especially for low-power high precision applications.

Low Input Referred Noise

The device AS2333 is chopper stabilized amplifier, the flicker noise is reduced greatly because of this technique. The zero-drift chopper-stabilized amplifiers are especially suited for accurate, high-gain amplification at lower frequencies. In general, they do not exhibit the higher bandwidth of linear operational amplifier, and the location of their clock frequency establishes a practical frequency limit on signal fidelity. This makes performance at low frequencies especially important, and the chopper-stabilized architecture further contributes to low frequency usefulness by eliminating the classic linear operational amplifier 1/f input voltage noise. Many high gain sensor applications are at low frequencies, making zero-drift amplifiers a natural choice for this function.

Below plots compared conventional amplifier voltage noise density behavior and zero-drift amplifier's, this 1/f noise elimination in zero-drift amplifier allows the AS2333 to have much lower noise at DC and low frequency compared to conventional low noise amplifier.



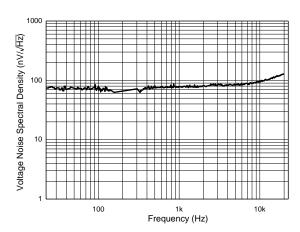


Figure 1. Input Voltage Noise in Conventional Amplifier (AZV832)

Figure 2. Input Voltage Noise in Zero-Drift Amplifier (AS2333)

Driving a Capacitive Load

The AS2333 can directly drive 200pF in unity-gain without oscillation. The unity-gain follower is the most sensitive configuration to capacitive loading. Capacitive loading directly on the output terminal can decrease the device's phase margin leading to high frequency ringing or oscillation.

To drive a heavier capacitive load, the circuit in Figure 3 can be used. The resistor R_{NULL} and C_L form a pole to increase stability by adding more phase margin to the system. The bigger R_{NULL} resistor value the more stable V_{OUT} is. Figure 4 and Figure 5 are AS2333 output pulse response waveforms with and without R_{NULL} 330 Ω for load conditions $C_L = 470pF$ and $R_L = 10k\Omega$.



Application Information (continued)

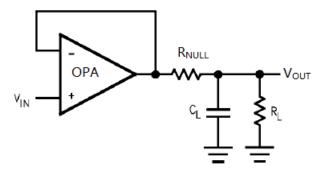


Figure 3. Capacitive Load with R_{NULL}

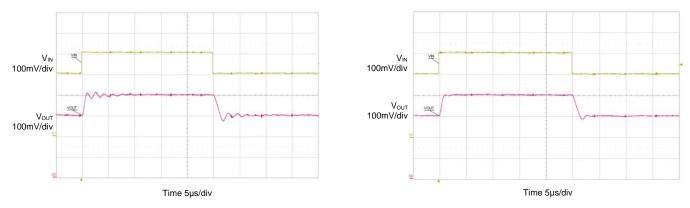


Figure 4. Test Result Without RNULL

Figure 5. Test Result with R_{NULL} 330 $\!\Omega$

Reducing capacitive load ringing and overshoot, the RC snubber circuit also can be used, shown in Figure 6, it does allow the amplifier to drive larger values of capacitance while maintaining a minimum of overshoot and ringing. Figure 7 shows AS2333 test result for capacitive load 470pF with snubber circuit.

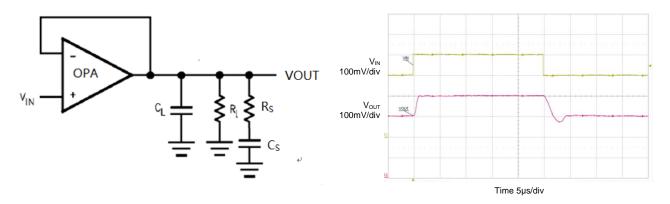


Figure 6. Circuit with Snubber Circuit

Figure 7. Test Result with Snubber Circuit



Application Information (continued)

Low-Side Current Monitor Application

Low-side current sensing is used to monitor the current through a load. This method can be used to detect over-current conditions and is often used in feedback control, as shown in Figure 8. A sense resistor is placed in series with the load to ground. Precision resistors are required for high accuracy and the resulting voltage drop is amplified using AS2333.

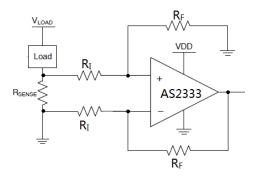


Figure 8. Low-Side Current Monitor Application

Differential Amplifier for Bridged Circuits

Sensors to measure strain, pressure, and temperature are often configured in a Wheatstone bridge circuit as shown in Figure 9. In the measurement, the voltage change that is produced is relatively small and needs to be amplified before going into an ADC. Precision amplifiers are recommended in these types of applications due to their high gain, low noise, and low offset voltage.

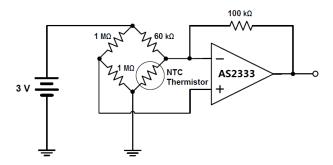
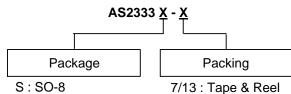


Figure 9. Bridge Circuit Amplification



Ordering Information



M8: MSOP-8

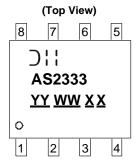
FGE: U-DFN3030-8 (Type E)

Part Number	Identification Packaging	Tape and Reel		
Part Number	Code	Packaging	Quantity	Part Number Suffix
AS2333S-13	AS2333	SO-8	2500/Tape & Reel	-13
AS2333M8-13	AS2333	MSOP-8	2500/Tape & Reel	-13
AS2333FGE-7 (Note 8)	ND	U-DFN3030-8 (Type E)	3000/Tape & Reel	-7

Note: 8. This part will be developed in future.

Marking Information

(1) SO-8



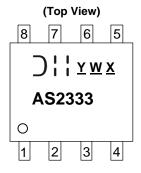
⊃¦¦: Logo

AS2333 : Identification Code YY : Year : 19, 20, 21~ WW : Week : 01~52; 52

represents 52 and 53 week

 $\underline{X}\underline{X}$: Internal Code

(2) MSOP-8



⊃¦¦: Logo

AS2333: Identification Code

Y: Year: 0 to 9

 $\overline{\underline{W}}$: Week: A to Z: 1 to 26 week; a to z: 27 to 52 week; z represents

52 and 53 week X: Internal Code

(3) U-DFN3030-8 (Type E)

(Top View)



ND : Identification Code

 \underline{Y} : Year : 0~9

 \underline{W} : Week: A~Z: 1~26 week; a~z: 27~52 week; z represents

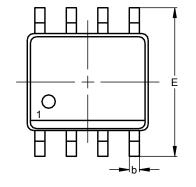
52 and 53 week X: Internal Code

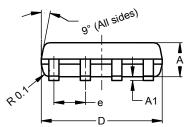


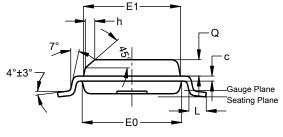
Package Outline Dimensions

Please see http://www.diodes.com/package-outlines.html for the latest version.

(1) Package Type: SO-8

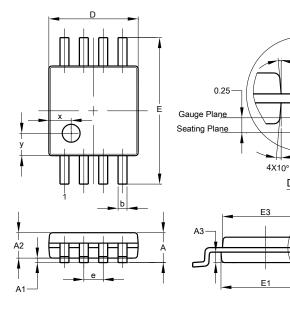






SO-8				
Dim	Min	Max	Тур	
Α	1.40	1.50	1.45	
A1	0.10	0.20	0.15	
b	0.30	0.50	0.40	
C	0.15	0.25	0.20	
D	4.85	4.95	4.90	
Е	5.90	6.10	6.00	
E1	3.80	3.90	3.85	
E0	3.85	3.95	3.90	
е			1.27	
h			0.35	
L	0.62	0.82	0.72	
ø	0.60	0.70	0.65	
All Dimensions in mm				

(2) Package Type: MSOP-8



	MSOP-8				
Dim	Min	Max	Тур		
Α	-	1.10			
A1	0.05	0.15	0.10		
A2	0.75	0.95	0.86		
A3	0.29	0.49	0.39		
b	0.22	0.38	0.30		
С	0.08	0.23	0.15		
D	2.90	3.10	3.00		
Е	4.70	5.10	4.90		
E1	2.90	3.10	3.00		
E3	2.85	3.05	2.95		
е	-	-	0.65		
L	0.40	0.80	0.60		
а	0°	8°	4°		
Х	-	-	0.750		
у	-	-	0.750		
All Dimensions in mm					

Detail C

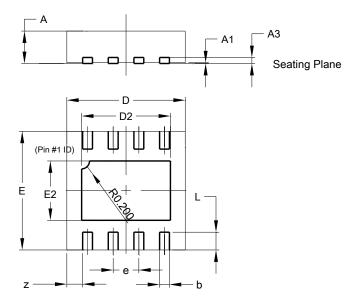
∠See Detail C



Package Outline Dimensions (continued)

Please see http://www.diodes.com/package-outlines.html for the latest version.

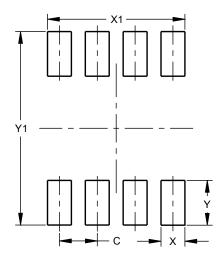
(3) Package Type: U-DFN3030-8 (Type E)



U-DFN3030-8						
	(Type E)					
Dim	Min	Max	Тур			
Α	0.57	0.63	0.60			
A1	0.00	0.05	0.02			
A3	-	-	0.15			
b	0.20	0.30	0.25			
D	2.95	3.05	3.00			
D2	2.15	2.35	2.25			
Е	2.95	3.05	3.00			
E2	1.40	1.60	1.50			
е	-	-	0.65			
L	0.30	0.60	0.45			
z	-	-	0.40			
All Dimensions in mm						

Suggested Pad Layout

(1) Package Type: SO-8



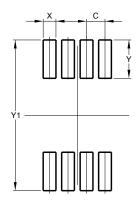
Dimensions	Value (in mm)
С	1.27
Х	0.802
X1	4.612
Υ	1.505
Y1	6.50



Suggested Pad Layout (continued)

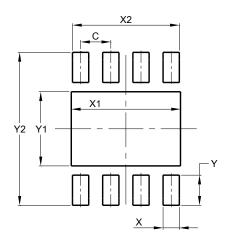
Please see http://www.diodes.com/package-outlines.html for the latest version.

(2) Package Type: MSOP-8



Dimensions	Value	
Dilliensions	(in mm)	
С	0.650	
Х	0.450	
Υ	1.350	
Y1	5.300	

(3) Package Type: U-DFN3030-8 (Type E)



Dimensions	Value (in mm)	
С	0.650	
Х	0.350	
X1	2.350	
X2	2.300	
Υ	0.650	
Y1	1.600	
Y2	3.300	

Mechanical Data

SO-8

- Moisture Sensitivity: Level 1 per J-STD-020
- Terminals: Finish Matte Tin Plated Leads, Solderable per MIL-STD-202, Method 208@3
- Weight: 0.075 grams (Approximate)

MSOP-8

- Moisture Sensitivity: Level 1 per J-STD-020
- Terminals: Finish Matte Tin Plated Leads, Solderable per MIL-STD-202, Method 208@3
- Weight: 0.025 grams (Approximate)



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