

## 1. Description

The UMW OPA2333, OPA333 series of CMOS operational amplifiers use a proprietary auto-calibration technique to simultaneously provide very low offset voltage (10  $\mu\text{V}$ , maximum) and near-zero drift over time and temperature. These miniature, high-precision, low quiescent current amplifiers offer high-impedance inputs that have a common-mode range 100 mV beyond the rails, and rail-to-rail output that swings within 50 mV of the rails. Single or dual supplies as low as 1.8 V ( $\pm 0.9$  V) and up to 5.5 V ( $\pm 2.75$  V) can be used. These devices are optimized for low-voltage, single-supply operation.

The OPAx333 family offers excellent CMRR without the crossover associated with traditional complementary input stages. This design results in superior performance for driving analog-to-digital converters (ADCs) without degradation of differential linearity.

The OPA333 (single version) is available in the 5-pin SOT-23, SOT, and 8-pin SOP packages, while the OPA2333 (dual version) is available in the 8-pin SOP packages. All versions are specified for operation from  $-40^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ .

## 2. Features

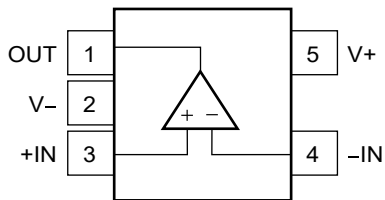
- Low Offset Voltage: 10  $\mu\text{V}$  (Maximum)
- Zero Drift: 0.05  $\mu\text{V}/^{\circ}\text{C}$  (Maximum)
- 0.01-Hz to 10-Hz Noise: 1.1  $\mu\text{V}_{\text{PP}}$
- Quiescent Current: 17  $\mu\text{A}$
- Single-Supply Operation
- Supply Voltage: 1.8V to 5.5V
- Rail-to-Rail input/Output
- microSize Packages: SC70 and SOT23

## 3. Applications

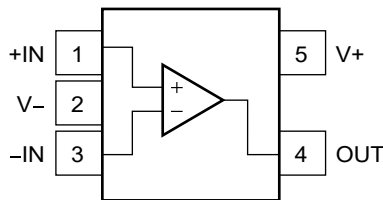
- Transducers
- Temperature Measurements
- Electronic Scales
- Medical instrumentation
- Battery-Powered Instruments
- Handheld Test Equipment



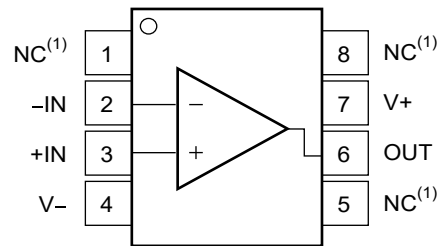
## 4.1 Pinning Information (OPA333)



**SOT23-5**



**SC70-5**



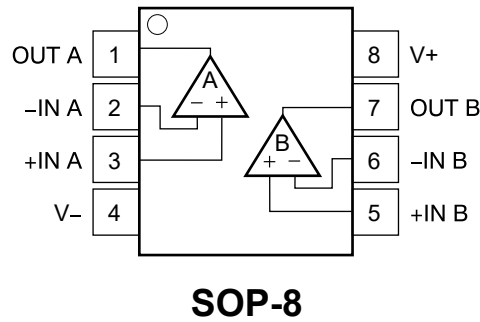
**SOP-8**

### Pin Functions

Name	PIN			I/O	Description
	SOP	SOT	SC70		
+IN	3	3	1	I	Noninverting input
-IN	2	4	3	I	Inverting input
NC	1,5,8	-	-	-	No internal connection (can be left floating)
OUT	6	1	4	O	Output
V+	7	5	5	-	Positive (highest) power supply
V-	4	2	2	-	Negative (lowest) power supply



## 4.2 Pinning Information (OPA2333)



### Pin Functions

PIN		I/O	Description
Name	SOP		
+IN	-	I	Noninverting input
+INA	3	I	Noninverting input, channel A
+INB	5	I	Noninverting input, channel B
-IN	-	I	Inverting input
-INA	2	I	Inverting input, channel A
-INB	6	I	Inverting input, channel B
OUT	-	O	Output
OUTA	1	O	Output, channel A
OUTB	7	O	Output, channel B
V+	8	-	Positive (highest) power supply
V-	4	-	Negative (lowest) power supply



## 5. Absolute Maximum Ratings

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

Parameter		Symbol	Min	Max	Units
Voltage	Supply voltage			7	V
	Signal input terminals <sup>(2)</sup>		-0.3	(V+)+0.3	V
Current	Signal input terminals <sup>(2)</sup>		-1	1	mA
	Output short circuit <sup>(3)</sup>		Continuous		
Operating junction temperature		T <sub>J</sub>		150	°C
Operating temperature		T <sub>A</sub>	-40	150	°C
Storage temperature		T <sub>STG</sub>	-65	150	°C

Notes:

(1) Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under Recommended Operating Conditions. 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 0.3 V beyond the supply rails should be current limited to 10 mA or less.

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

## 6. ESD Ratings

Parameter		Symbol	Value	Units
Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 <sup>(1)</sup>	V <sub>(ESD)</sub>	±4000	V
	Charged-device model (CDM), per JEDEC specification JESD22-C101 <sup>(2)</sup>		±1000	V

Notes:

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.

(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.



## 7. Recommended Operating Conditions

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

Parameter	Min	Max	Units
Supply voltage, $V_s$	1.8	5.5	V
Specified temperature	-40	125	°C

### 8.1 Thermal Information (OPA333)

Thermal Metric <sup>(1)</sup>	Symbol	D(SOIC)	DBV(SOT)	DCK(SC70)	Units
		8 Pins	5 Pins	5 Pins	
Junction-to-ambient thermal resistance	$R_{\theta JA}$	140.1	220.8	298.4	°C/W
Junction-to-case (top) thermal resistance	$R_{\theta JC(top)}$	89.8	97.5	65.4	°C/W
Junction-to-board thermal resistance	$R_{\theta JB}$	80.6	61.7	97.1	°C/W
Junction-to-top characterization parameter	$\psi_{JT}$	28.7	7.6	0.8	°C/W
Junction-to-board characterization parameter	$\psi_{JB}$	80.1	61.1	95.5	°C/W
Junction-to-case(bottom)thermal resistance	$R_{\theta JC(bot)}$	-	-	-	°C/W

### 8.2 Thermal Information (OPA2333)

Thermal Metric <sup>(1)</sup>	Symbol	D(SOP)	Units
		8 Pins	
Junction-to-ambient thermal resistance	$R_{\theta JA}$	124	°C/W
Junction-to-case (top) thermal resistance	$R_{\theta JC(top)}$	73.7	°C/W
Junction-to-board thermal resistance	$R_{\theta JB}$	64.4	°C/W
Junction-to-top characterization parameter	$\psi_{JT}$	18	°C/W
Junction-to-board characterization parameter	$\psi_{JB}$	63.9	°C/W
Junction-to-case(bottom)thermal resistance	$R_{\theta JC(bot)}$	-	°C/W



## 9. Electrical Characteristics

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

Parameter	Symbol	Conditions	Min	Typ	Max	Units
<b>OFFSET VOLTAGE</b>						
Input offset voltage	$V_{OS}$	$V_S=5\text{V}$		2	10	$\mu\text{V}$
Input offset voltage drift	$dV_{OS}/dT$	$T_A=-40^\circ\text{C}$ to $125^\circ\text{C}$		0.02	0.05	$\mu\text{V}/^\circ\text{C}$
Power-supply rejection ratio	PSRR	$V_S=1.8\text{V}$ to $5.5\text{V}$ , $T_A=-40^\circ\text{C}$ to $125^\circ\text{C}$		1	5	$\mu\text{V}/\text{V}$
Long-term stability <sup>(1)</sup>			See note <sup>(1)</sup>			$\mu\text{V}$
Channel separation, dc				0.1		$\mu\text{V}/\text{V}$
<b>INPUT BIAS CURRENT</b>						
Input bias current	$I_B$	$T_A=25^\circ\text{C}$		$\pm 70$	$\pm 200$	pA
		$T_A=-40^\circ\text{C}$ to $125^\circ\text{C}$		$\pm 150$		pA
Input offset current	$I_{OS}$			$\pm 140$	$\pm 400$	pA
<b>NOISE</b>						
Input voltage noise		$f=0.01\text{Hz}$ to $1\text{Hz}$		0.3		$\mu\text{V}_{PP}$
		$f=0.1\text{Hz}$ to $10\text{Hz}$		1.1		$\mu\text{V}_{PP}$
Input current noise	$i_n$	$f=10\text{Hz}$		100		$\text{fA}/\sqrt{\text{Hz}}$
<b>INPUT VOLTAGE</b>						
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 $125^\circ\text{C}$	106	130		dB
<b>INPUT CAPACITANCE</b>						
Differential				2		pF
Common-mode				4		pF
<b>OPEN-LOOP GAIN</b>						
Open-loop voltage gain	$A_{OL}$	$(V_-)+100\text{mV} < V_O < (V_+)-100\text{mV}$ $R_L=10\text{k}\Omega$ , $T_A=-40^\circ\text{C}$ to $125^\circ\text{C}$	106	130		dB
<b>FREQUENCY RESPONSE</b>						
Gain-bandwidth product	GBW	$C_L=100\text{pF}$		350		kHz
Slew rate	SR	$G=+1$		0.16		$\text{V}/\mu\text{s}$



Parameter	Symbol	Conditions	Min	Typ	Max	Units
<b>OUTPUT</b>						
Voltage output swing from rail		$R_L=10k\Omega$		30	50	mV
		$R_L=10k\Omega, T_A=-40^\circ\text{C to }125^\circ\text{C}$			70	mV
Short-circuit current	$I_{SC}$			$\pm 5$		mA
Capacitive load drive	$C_L$		See Typical Characteristics			
Open-loop output impedance		$f=350kHz, I_o=0A$		2		k $\Omega$
<b>POWER SUPPLY</b>						
Specified voltage range	$V_S$		1.8		5.5	V
Quiescent current per amplifier	$I_Q$	$I_o=0A$		17	25	$\mu A$
		$T_A=-40^\circ\text{C to }125^\circ\text{C}$			28	$\mu A$
Turn-on time		$V_S=5V$		100		$\mu s$
<b>TEMPERATURE</b>						
Specified range	$T_A$		-40		125	$^\circ\text{C}$
Operating range			-40		150	$^\circ\text{C}$
Storage range	$T_{STG}$		-65		150	$^\circ\text{C}$

(1) 300-hour life test at 150°C demonstrated randomly distributed variation of approximately 1 $\mu V$ .



## 10.1 Typical characteristic

<p>Figure 1: Offset Voltage Production Distribution</p>	<p>Figure 2: Offset Voltage Drift Production Distribution</p>
<p>Figure 3: Open-Loop Gain and Phase vs Frequency</p>	<p>Figure 4: Common-Mode Rejection Ratio vs Frequency</p>
<p>Figure 5: Power-Supply Rejection Ratio vs Frequency</p>	<p>Figure 6: Output Voltage Swing vs Output Current</p>



## 10.2 Typical characteristic

<p>Figure 7: Input Bias Current vs Common-Mode Voltage</p>	<p>Figure 8: Input Bias Current vs Temperature</p>
<p>Figure 9: Quiescent Current vs Temperature</p>	<p>Figure 10: Large-Signal Step Response</p>
<p>Figure 11: Small-Signal Step Response</p>	<p>Figure 12: Positive Overvoltage Recovery</p>

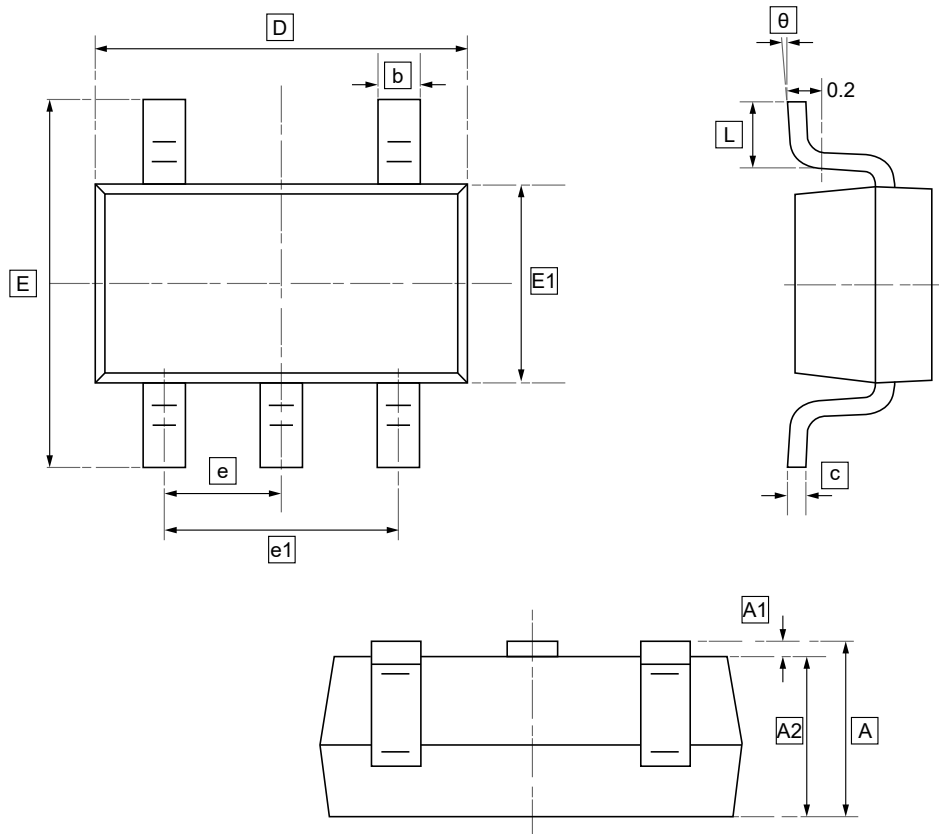


## 10.3 Typical characteristic

<p style="text-align: center;">Time (50µs/div)</p>	<p style="text-align: center;">Gain (dB)</p>
<p style="text-align: center;">Figure 13: Negative Overvoltage Recovery</p>	<p style="text-align: center;">Figure 14: Settling Time vs Closed-Loop Gain</p>
<p style="text-align: center;">Load Capacitance (pF)</p>	<p style="text-align: center;">1s/div</p>
<p style="text-align: center;">Figure 15: Small-Signal Overshoot vs Load Capacitance</p>	<p style="text-align: center;">Figure 16: 0.1-Hz to 10-Hz Noise</p>
<p style="text-align: center;">Frequency (Hz)</p>	
<p style="text-align: center;">Figure 17: Current and Voltage Noise Spectral Density vs Frequency</p>	



## 11.1 SOT-23-5 Package Outline Dimensions

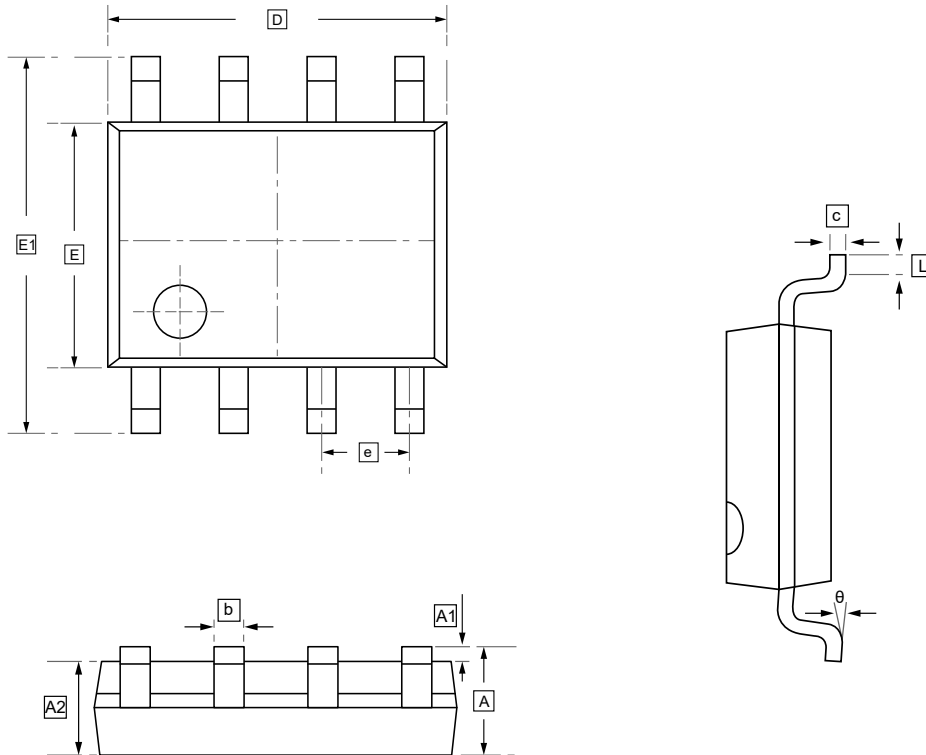


### DIMENSIONS (mm are the original dimensions)

Symbol	A	A1	A2	b	c	D	E1	E	e	e1	L	θ
Min	1.050	0.000	1.050	0.300	0.100	2.820	1.500	2.650	0.950	1.800	0.300	0°
Max	1.250	0.100	1.150	0.500	0.200	3.020	1.700	2.950	BSC	2.000	0.600	8°



## 11.2 SOP-8 Package Outline Dimensions

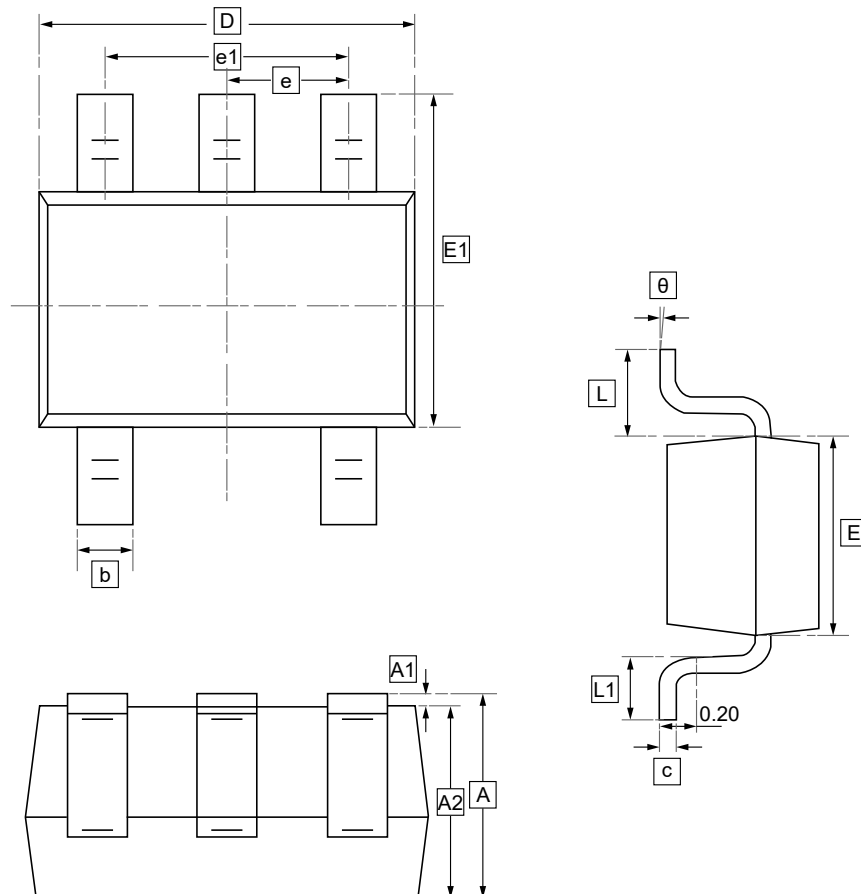


### DIMENSIONS (mm are the original dimensions)

Symbol	A	A1	A2	b	c	D	E	E1	e	L	θ
Min	1.350	0.000	1.350	0.330	0.170	4.700	3.800	5.800	1.270	0.400	0°
Max	1.750	0.100	1.550	0.510	0.250	5.100	4.000	6.200	BSC	1.270	8°



## 11.3 SC70-5 Package Outline Dimensions

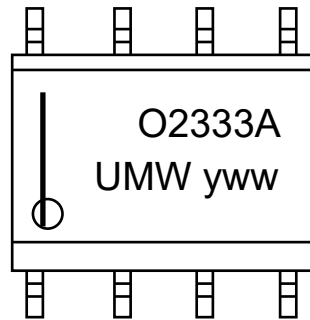


### DIMENSIONS (mm are the original dimensions)

Symbol	A	A1	A2	b	c	D	E	E1	e	e1	L	$\theta$
Min	0.90	0.00	0.90	0.15	0.08	2.05	1.15	2.15	0.65	1.20	0.26	7°
Max	1.10	0.10	1.00	0.35	0.15	2.25	1.35	2.45	TYP	1.40	0.46	REF.



## 12. Ordering information



yww: Batch Code

Order Code	Marking	Package	Base QTY	Delivery Mode
UMW OPA2333AIDR	O2333A	SOP-8	2500	Tape and reel
UMW OPA333AIDR	O333A	SOP-8	2500	Tape and reel
UMW OPA333AIDBVR	OAXQ	SOT23-5	3000	Tape and reel
UMW OPA333AIDCKR	BQY	SC70-5	3000	Tape and reel



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