High-Precision, Rail-to-Rail I/O Operational Amplifier

General Description

The HTC6133(single) and HTC6233(dual) are high-precision, low-quiescent current amplifier which can offer high input impedance and rail-to-rail input and output. The amplifier uses auto-zeroing techniques to provide low offset voltage(2 μV type) and near zero-drift over time and temperature.

Either single or dual supplies can be used in the range from 2.3V to 5.5V (±1.15V to ±2.75V)

The HTC6133 is available in SC70-5,SOT23-5, MSOP-8 and SOP-8.The HTC6233 is available in MSOP-8 and SOP-8. All versions ae specified for operation from -40 ℃ to +125 ℃.

Features

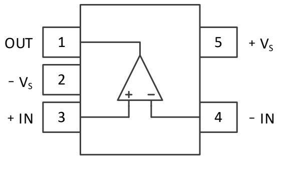
- Low Offset Voltage：2 μV(Type)
- Zero-Drift：0.03 μV/℃
- Low Noise：48 nV/$\sqrt{Hz}$
  - 0.1-Hz to 10-Hz Noise：0.8 μVpp
- Excellent DC Precision：
  - Open-Loop Gain: 135dB
  - PSRR: 110dB
  - CMRR: 110dB
- Gain Bandwidth: 0.4 MHz
- Quiescent Current: 20 μA(Type)
- Supply Range: ±1.15V to ±2.75V
- Rail-to-Rail Input and Output

Application

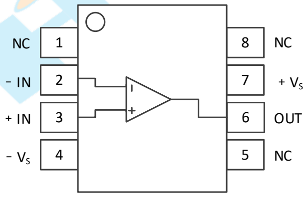
- Bridge Amplifier
- Strain Gauges
- Transducer Applications
- Temperature Measurement
- Electronic Scales
- Medical Instrumentation
- Resistance Temperature Detectors
- Handheld Test Equipment

Pin Configurations

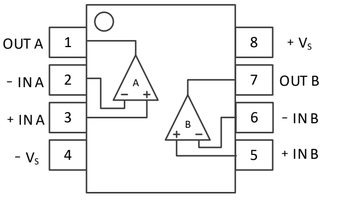
HTC6133
SC70-5/SOT23-5



HTC6133
MSOP-8/SO-8



HTC6233
MSOP-8/SO-8



Pin Description

Symbol	Description
–IN	Inverting Input of the Amplifier. The Voltage can go from (V_{S-}) to (V_{S+}).
+IN	Non-Inverting Input of Amplifier. This pin has the same voltage range as –IN.
$+V_S$	Positive Power Supply. The Voltage is from 2.3V to 5.5V(±1.15V to ±2.75V).
$–V_S$	Negative Power Supply. It is normally tied to ground.
OUT	Amplifier Output.
N/C	No Connection.

Ordering Information

Type Number	Package Name	Package Quantity	Marking Code
HTC6133XC5/R6	SC70-5	Tape and Reel,3000	C13XX
HTC6133XT5/R6	SOT23-5	Tape and Reel,3000	C13XX
HTC6133XS8/R8	SOP-8	Tape and Reel,4000	C6133X
HTC6133XV8/R6	MSOP-8	Tape and Reel,3000	C6133X
HTC6233XS8/R8	SOP-8	Tape and Reel,4000	C6233X
HTC6233XV8/R6	MSOP-8	Tape and Reel,3000	C6233X

Recommended Operating Conditions

- Operating voltage range: 2.1V to 5.5V(±1.05V to ±2.75V)
- Specified temperature range: -40℃ to 125℃

High-Precision, Rail-to-Rail I/O, 45-V Operational Amplifier

Absolute Maximum Ratings

Attention: Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

Parameter	Symbol	Absolute Maximum Rating	Unit
Supply Voltage		±3，+6(Single)	V
Input terminal	Voltage	V_{S-}-0.5 to V_{S+}+0.5	V
	Differential Voltage	±5	V
Temperature	Operating(2), T_A	-55 to 150	℃
	Storage , T_{stg}	-65 to 150	℃
	Junction , T_J	150	℃
Electrostatic Discharge Voltage	HBM	8	kV

(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) Provided device does not exceed maximum junction temperature (T_J) at any time.

Electrical Characteristics

V_S=+5V, T_A=25 ℃, V_{CM}=V_S/2, V_O=V_S/2, R_L=10kΩ connected to V_S/2, unless otherwise noted.

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
INPUT CHARACTERISTICS						
V_{OS}	Input offset Voltage			2	15	μV
V_{OS} TC	Offset voltage drift	T_A=-40℃ to + 125℃		0.03		μV/℃
I_B	Input bias current	V_{CM}=V_S/2		±100		pA
I_{OS}	Input offset current			±100		pA
V_{CM}	Common-mode Voltage range	T_A=-40℃ to + 125℃	Vs-		Vs+	V
CMRR	Common-mode rejection ratio	V_{S-}<V_{CM}< V_{S+}	90	110		dB
		T_A=-40℃ to + 125℃	85			dB
A_{VOL}	Open-loop voltage gain	V_{S-}+0.3V<V_O<V_{S+}-0.3V	105	135		dB
		T_A=-40℃ to + 125℃	100			dB
OUTPUT CHARACTERISTICS						
V_{OH}	High output voltage swing	R_L=10kΩ	(Vs+) -12	(Vs+) -4		mV
		T_A=-40℃ to + 125℃	(Vs+) -18			mV
V_{OL}	Low output voltage swing	R_L=10kΩ		(Vs-) +4	(Vs-) +12	mV
		T_A=-40℃ to + 125℃			(Vs-) +18	mV
I_{SC}	Short-circuit current	Source current	55	65		mA
		T_A=-40℃ to + 125℃	50			mA
		Sink current	48	55		mA
		T_A=-40℃ to + 125℃	45			mA
POWER SUPPLY						
PSRR	Power supply rejection ratio	V_S=2.1V to 5.5V	90	110		dB
		T_A=-40℃ to +125℃	80			dB
I_Q	Quiescent current			20	28	μA
		T_A=-40℃ to + 125℃			35	μA
NOISE						
e_n	Input voltage noise	f=0.1Hz to 10Hz		800		nVpp
		F=1KHz		48		nV/√Hz
DYNAMIC PERFORMANCE						
GBW	Gain bandwidth product			0.4		MHz
SR	Slew rate	G =+1		0.1		V/μs
t_{OR}	Overload recovery time	G =-10		20		μs

High-Precision, Rail-to-Rail I/Output Operational Amplifier

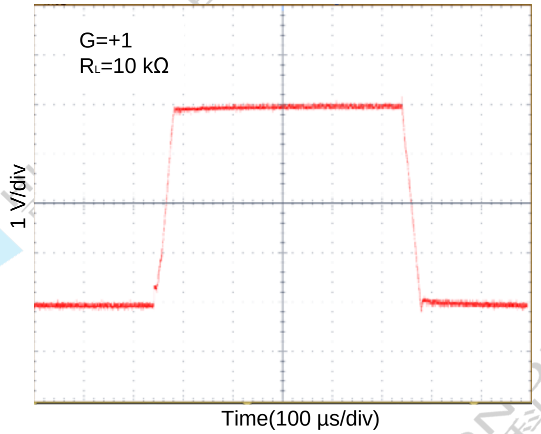
Electrical Characteristics

V_S=+2.7V, T_A=25 ℃, V_{CM}=V_S/2, V_O=V_S/2, R_L=10kΩ, R_L=10kΩ connected to V_S/2, unless otherwise noted.

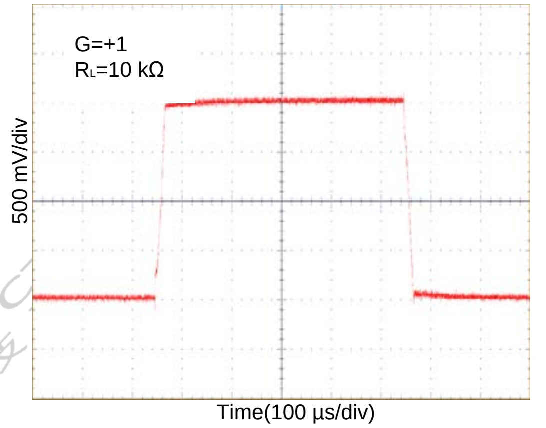
Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
INPUT CHARACTERISTICS						
V_{OS}	Input offset Voltage			4	20	μV
V_{OS} TC	Offset voltage drift	T_A=-40℃ to + 125℃		0.03		μV/℃
I_B	Input bias current	V_{CM}=V_S/2		±100		pA
I_{OS}	Input offset current			±100		pA
V_{CM}	Common-mode Voltage range	T_A=-40℃ to + 125℃	V_{S-}		V_{S+}	V
CMRR	Common-mode rejection ratio	V_{S-}<V_{CM}< V_{S+}	90	110		dB
		T_A=-40℃ to + 125℃	80	100		dB
A_{VOL}	Open-loop voltage gain	V_{S-}+0.3V<V_O< V_{S+}-0.3V	105	135		dB
		T_A=-40℃ to + 125℃	95			dB
OUTPUT CHARACTERISTICS						
V_{OH}	High output voltage swing	R_L=10kΩ	（Vs+）-12	（Vs+）-3		mV
		T_A=-40℃ to + 125℃	（Vs+）-18			mV
V_{OL}	Low output voltage swing	R_L=10kΩ		（Vs-）+3	（Vs-）+12	mV
		T_A=-40℃ to + 125℃			（Vs-）+18	mV
I_{SC}	Short-circuit current	Source current	17	24		mA
		T_A=-40℃ to + 125℃	14			mA
		Sink current	15	20		mA
		T_A=-40℃ to + 125℃	12			mA
POWER SUPPLY						
PSRR	Power supply rejection ratio	V_S=2.1V to 5.5V	90	110		dB
		T_A=-40℃ to +125℃	80			
I_Q	Quiescent current			18	25	μA
		T_A=-40℃ to + 125℃			35	
NOISE						
e_n	Input voltage noise	f=0.1Hz to 10Hz f=1KHz		800 48		nVpp nV/√Hz
DYNAMIC PERFORMANCE						
GBW	Gain bandwidth product			0.4		MHz
SR	Slew rate	G =+1		0.1		V/μs
t_{OR}	Overload recovery time	G =-10		20		μs

Type Performance Characteristics

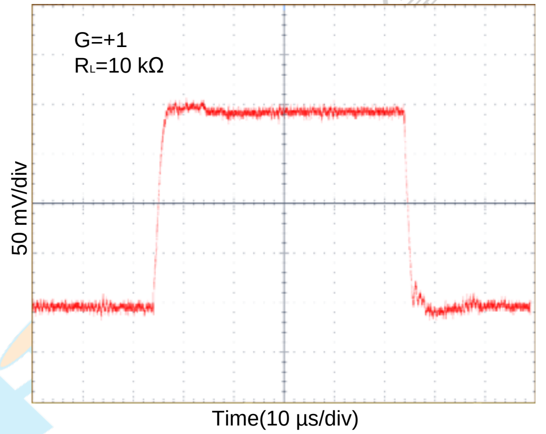
V_S=+5V, T_A=25℃, V_{CM}=V_S/2, V_O=V_S/2, R_L=10kΩ connected to V_S/2, unless otherwise noted.



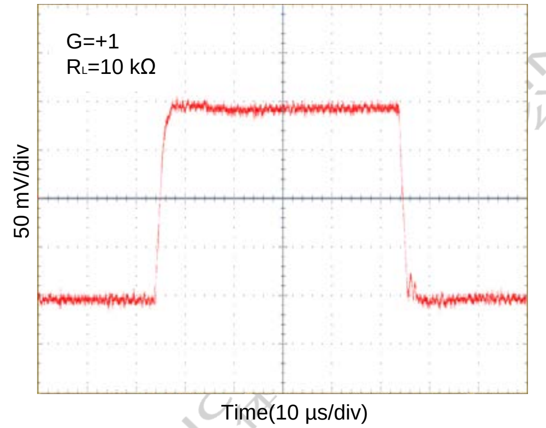
LARGE-SIGNAL STEP RESPONSE at +5V



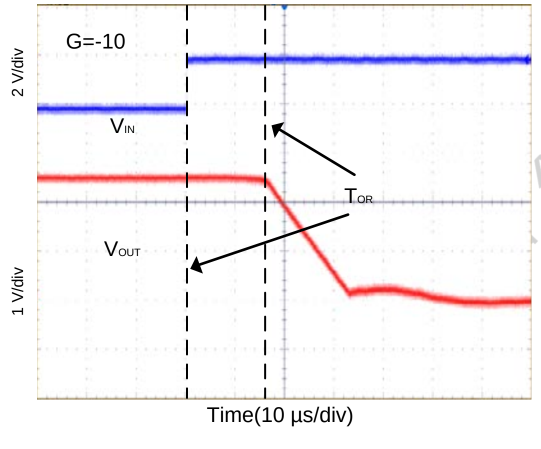
LARGE-SIGNAL STEP RESPONSE at +2.7V



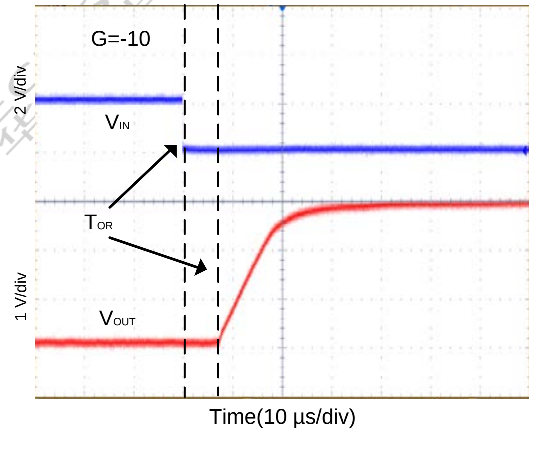
SMALL-SIGNAL STEP RESPONSE at +5V



SMALL-SIGNAL STEP RESPONSE at +2.7V



POSITIVE OVERLOAD RECOVERY

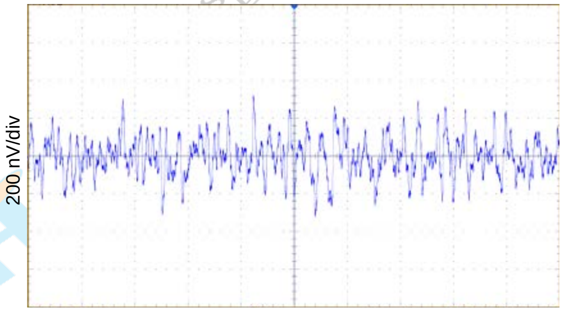


NEGATIVE OVERLOAD RECOVERY

High-Precision, Rail-to-Rail I/O Operational Amplifier

Type Performance Characteristics

V_S=+5V,T_A=25 ℃,V_{CM}=V_S/2,V_O=V_S/2,R_L=10kΩ,R_L=10kΩ connected to V_S/2,unless otherwise noted.



0.1Hz to 10Hz noise

Application Notes

Application Information

The HTC6X33 operational amplifier combines precision offset and drift with excellent overall performance, making it ideal for many precision applications. The precision offset drift of only 0.085 μV/℃ provides stability over the entire temperature range. In addition, the device pairs excellent CMRR, PSRR, and AOL dc performance with outstanding low-noise operation. As with all amplifiers, applications with noisy or high-impedance power supplies require decoupling capacitors close to the device pins. In most cases, 0.1-μF capacitors are adequate.

Operating Characteristics

The HTC6X33 is specified for operation from 2.1 V to 5.5 V (±1.05 V to ±2.75 V). Many specifications apply from –40 ℃ to +125 ℃. Parameters that can exhibit significant variance with regard to operating voltage or temperature are presented in *Typical Characteristics*.

Capacitive Load and Stability

The unity-gain follower (buffer) is the most sensitive configuration to capacitive loading. Direct capacitive loading reduces the phase margin of amplifiers and this results in ringing or even oscillation. Applications that require greater capacitive drive capability should use an isolation resistor between the output and the capacitive load like the circuit in Figure 2. The isolation resistor R_{ISO} and the load capacitor C_L form a zero to increase stability. The bigger the R_{ISO} resistor value, the more stable V_{out} will be. Note that this method results in a loss of gain accuracy because R_{ISO} forms a voltage divider with the R_L.

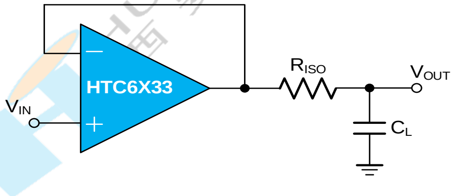


Figure 1. Indirectly Driving Heavy Capacitive Load

An improvement circuit is shown in Figure 3. It provides DC accuracy as well as AC stability. The RF provides the DC accuracy by connecting the inverting signal with the output.

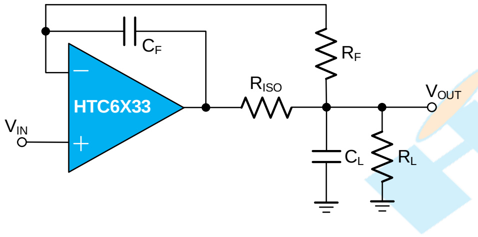


Figure2. Indirectly Driving Capacitive Load with DC Accuracy

Input Bias Current Clock Feedthrough

The HTC6X33 use switching on the inputs to correct for the intrinsic offset and drift of the amplifier. Charge injection from the integrated switches on the inputs can introduce very short transients in the input bias current of the amplifier. The extremely short duration of these pulses prevents the device from being amplified. However, the devices may be coupled to the output of the amplifier through the feedback network. The most effective method to prevent transients in the input bias current from producing additional noise at the amplifier output is to use a low-pass filter such as an RC network.

High-Precision, Rail-to-Rail I/O Operational Amplifier

Application Notes

Layout Guidelines

For best operational performance of the device, use good printed circuit board (PCB) layout practices, including:

A. Place the external components as close to the device as possible. This configuration prevents parasitic errors (such as the Seebeck effect) from occurring.
B. To reduce parasitic coupling, run the input traces as far away from the supply lines and digital signal as possible.
C. Low-ESR, 0.1-μF ceramic bypass capacitors must be connected between each supply pin and ground, placed as close to the device as possible. A single bypass capacitor from V+ to ground is applicable to single supply applications.
D. Consider a driven, low-impedance guard ring around the critical traces. A guard ring can significantly reduce leakage currents from nearby traces that are at different potentials.

Low-side Current Monitor

Figure 4 shows the HTC6X33 configured in a low-side current-sensing application. The load current (ILOAD) creates a voltage drop across the shunt resistor (RSHUNT). This voltage is amplified by the HTC6X33.

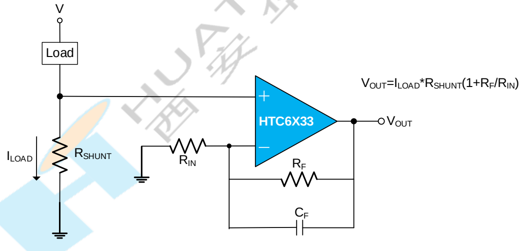


Figure 3. Low-Side Current Monitor

Bridge Amplifier

Figure 5 shows the basic configuration for a bridge amplifier.

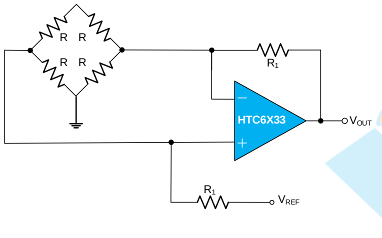


Figure 4. Bridge Amplifier

Programmable Power Supply

Figure 6 shows the HTC6X33 configured as a precision programmable power supply using DAC and power amplifier. The HTC6X33 in the front-end provides precision and low drift across a wide range of inputs and conditions.

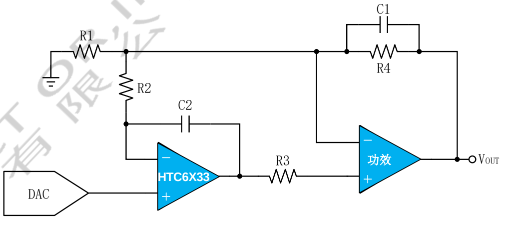
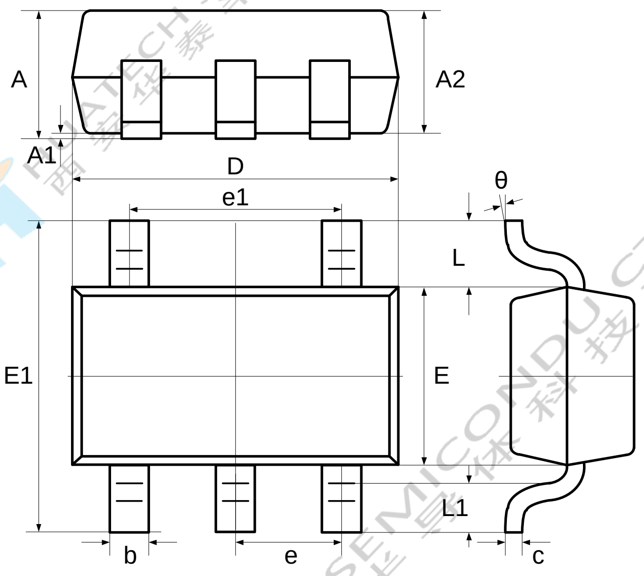


Figure 5. Programmable Power Supply

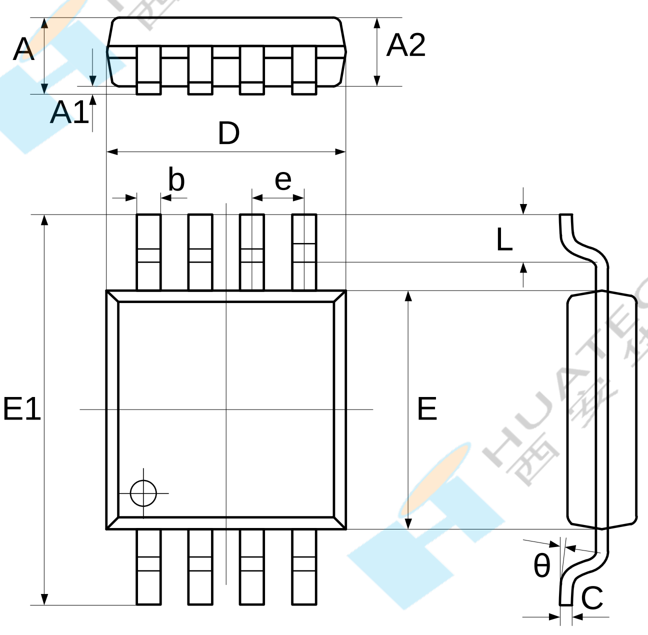
Package Outlines

SC70-7/SOT23-5



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.040	1.350	0.042	0.055
A1	0.040	0.150	0.002	0.006
A2	1.000	1.200	0.041	0.049
b	0.380	0.480	0.015	0.020
c	0.110	0.210	0.004	0.009
D	2.720	3.120	0.111	0.127
E	1.400	1.800	0.057	0.073
E1	2.600	3.000	0.106	0.122
e	0.950 typ.		0.037 typ.	
e1	1.900 typ.		0.078 typ.	
L	0.700 ref.		0.028 ref.	
L1	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°

MSOP-8

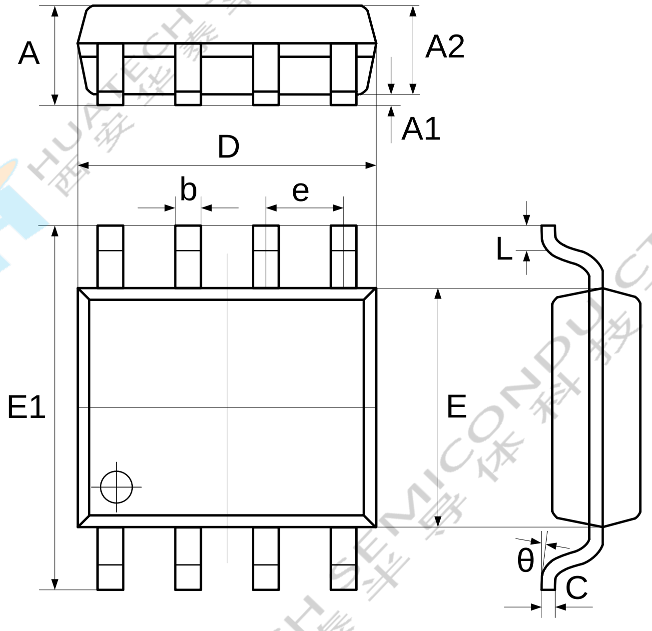


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0.800	1.100	0.033	0.045
A1	0.050	0.150	0.002	0.006
A2	0.750	0.950	0.031	0.039
b	0.290	0.380	0.012	0.016
C	0.150	0.200	0.006	0.008
D	2.900	3.100	0.118	0.127
E	2.900	3.100	0.118	0.127
E1	4.700	5.100	0.192	0.208
e	0.650 typ.		0.026 typ.	
L	0.400	0.700	0.016	0.029
θ	0°	8°	0°	8°

High-Precision, Low-Noise, Rail-to-Rail Output, 45-V, Zero-Drift Operational Amplifier

Package Outlines

SOP-8



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.370	1.670	0.056	0.068
A1	0.070	0.170	0.003	0.007
A2	1.300	1.500	0.053	0.061
b	0.306	0.506	0.013	0.021
C	0.203 typ.		0.008 typ.	
D	4.700	5.100	0.192	0.208
E	3.820	4.020	0.156	0.164
E1	5.800	6.200	0.237	0.253
e	1.270 typ.		0.050 typ.	
L	0.450	0.750	0.018	0.306
θ	0°	8°	0°	8°

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