LM358

Dual Operational Amplifiers

General Description

The LM358 series consists of two independent, high gain, internally frequency compensated operational amplifiers which were designed specifically to operate from a single power supply over a wide range of voltages. Operation from split power supplies is also possible and the low power supply current drain is independent of the magnitude of the power supply voltage.

Application areas include transducer amplifiers, dc gain blocks and all the conventional op amp circuits which now can be more easily implemented in single power supply systems. For example, the LM358 series can be directly operated from the standard +5V power supply voltage which is used in digital systems and will easily provide the required interface electronics without requiring an additional ±15V power supply. The LM358 amplifier available in micro-sized packaging, such as the standard packages including SOP8, and TSSOP8.

Ordering Information

Part Number	Marking	Package
LM358_S8	LM358 YYWW	SOP8
LM358_TS8	LM358 YYWW	TSSOP8

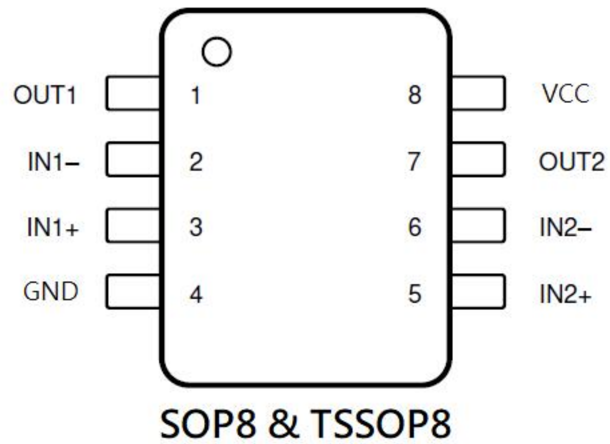
Features

- Internally frequency compensated for unity gain
- Large dc voltage gain: 100 dB
- Very low supply current drain (350μA/ch)
- Wide bandwidth (unity gain): 700KHz
- Low input offset voltage: 3mV
- Wide power supply range:
  Single supply: 3V to 40V
  Dual supplies: ±1.5V to ±20V
- Input common-mode voltage range includes ground
- Differential input voltage range equal to the power supply voltage
- SOP8 & TSSOP8 Packages

Applications

- Merchant network and server power supply units
- Multi-function printers
- Power supplies and mobile chargers
- Motor control: AC induction, brushed DC, brushless DC, high-voltage, low-voltage, permanent magnet, and stepper motor
- Desktop PC and motherboard
- Indoor and outdoor air conditioners
- Washers, dryers, and refrigerators
- AC inverters, string inverters, central inverters, and voltage frequency drives
- Uninterruptible power supplies
- Electronic point-of-sale systems

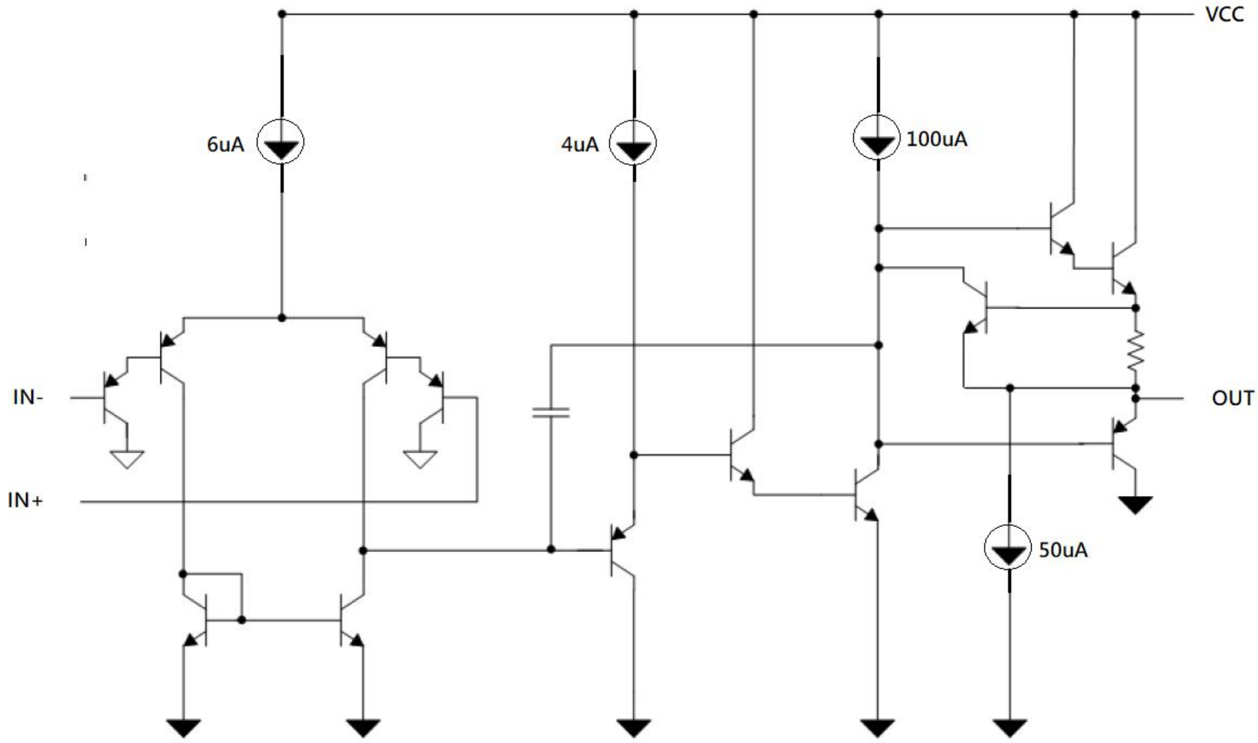
Pin Configuration



Pin Assignment

Pin Name	SOP8 TSSOP8 Pin No	Pin Function
OUT1	1	Channel 1 Output
IN1-	2	Channel 1 Inverting Input
IN1+	3	Channel 1 Non-inverting Input
GND	4	Ground
IN2+	5	Channel 2 Non-inverting Input
IN2-	6	Channel 2 Inverting Input
OUT2	7	Channel 2 Output
VCC	8	Chip Supply Voltage

Function Block Diagram



Absolute Maximum Ratings (Note1)

- Supply Voltage V_{Supply} = V_{CC} - GND -- 45V
- Differential Input Voltage, V_{ID} -- ±45V
- Input Voltage V_{IN1+}, V_{IN1-}, V_{IN2+}, V_{IN2-}, -- -0.3V to 45V
- Power Dissipation, PD@T_A=25℃, SOP-8--0.8W
- Thermal Resistance, θ_{JA}, SOP-8---125℃/W
- Power Dissipation, PD@T_A=25℃, TSSOP-8--0.58W
- Thermal Resistance, θ_{JA}, TSSOP-8---172℃/W
- Junction Temperature-- -40°C to125°C
- Lead Temperature (Soldering, 10 sec.)--- 300°C
- Storage Temperature -- –65°C to 150°C

ESD Rating

- HBM(per ANSI/ESDA/JEDEC JS-001) ------------------------------------ 2KV
- CDM(per JEDEC specification JESD22-C10) -- 1KV

Recommended Operating Conditions

- Supply Voltage V_{Supply} = V_{CC} - GND -- 40V
- Differential Input Voltage, V_{ID} -- ±40V
- Input Voltage V_{IN1+}, V_{IN1-}, V_{IN2+}, V_{IN2-}, --- 40V
- Junction Temperature -- -40°C to 125°C
- Ambient Temperature -- -40°C to 85°C

Electrical Characteristics

V_{CC}=5V, T_A=25℃, unless otherwise specified

Parameter	Symbol	Conditions		Min	Typ	Max	Unit
Input Offset Voltage	V_{IO}	V_{CC} = 5V to MAX, $V_{IC} = V_{ICR(min)}$, V_O = 1.4V	25°C		3	7	mV
			Full range			9	
Average Temperature Coefficient of Input Offset Voltage	αV_{IO}		Full range		7		µV/°C
Input Offset Current	I_{IO}	V_O = 1.4V	25°C		2	50	nA
			Full range			150	
Average Temperature Coefficient of Input Offset Current	αI_{IO}		Full range		10		pA/°C
Input Bias Current	I_{IB}	V_O = 1.4V	25°C		-20	-250	nA
			Full range			-500	
Common-mode Input Voltage Range	V_{ICR}	V_{CC} = 5V to MAX	25°C	0 to Vcc-1.5			V
			Full range	0 to Vcc-2.0			
High-level Output Voltage	V_{OH}	V_{CC} = MAX, R_L = 2kΩ	Full range	26			V
		V_{CC} = MAX, $R_L \geq$ 10kΩ	Full range	27	28		
Low-level Output Voltage	V_{OL}	$R_L \geq$ 10kΩ	Full range		5	20	mV
Large-signal Differential Voltage Amplification	A_{VD}	V_{CC} = 15V, V_{OUT} = 1V to 11V, $R_L \geq$ 2kΩ	25°C	25	100		V/mV
			Full range	15			
Common-mode Rejection Ratio	CMRR	V_{CC} = 5V to MAX, $V_{IC} = V_{ICR(min)}$	25°C	65	80		dB
Supply Voltage Rejection Ratio ($\Delta V_{CC}/\Delta V_{IO}$)	k_{SVR}	V_{CC} = 5V to MAX	25°C	65	100		dB
Crosstalk Attenuation	V_{O1}/V_{O2}	f =1 kHz to 20 kHz	25°C		120		dB
Output Current	I_{OUT}	V_{CC} = 15V, V_{ID} = 1V, V_O = 0	25°C	-30	-50		mA
			Full range	-20			
		V_{CC} = 15V, V_{ID} = -1V, V_O = 15V	25°C	15	35		
			Full range	7			
		V_{CC} = 15V, V_{ID} = -1V, V_O = 2V	25°C	15	28		mA
		V_{ID} = - 1V, V_O = 200mV	25°C	12	50		µA
Short-circuit Output Current	I_{OS}	V_{ID} = - 1V, V_O = 15V	25°C		50	70	mA

Supply Current (two amplifiers)	I_{CC}	V_O = 2.5V, No load	Full range		0.7	1.2	mA
		V_{CC} = MAX, V_O = 0.5V_{CC}, No load	Full range		1	2	
Slew Rate	SR	V_{CC} = 15V, V_{IN} = 0.5 to 3V, R_L = 2kΩ, C_L = 100pF, unity gain	25°C		0.7		V/µs
Gain Bandwidth	GBW	V_{CC} = 30V, f = 100kHz, V_{IN} = 10mV, R_L = 2kΩ, C_L = 100pF	25°C		700		kHz
Total Harmonic Distortion	THD	f = 1kHz, A_V = 20dB, R_L = 2kΩ, V_O = 2Vpp, C_L = 100pF,	25°C		0.04		%

*All characteristics are measured under the open-loop conditions with zero common-mode input voltage, unless otherwise specified. MAX V_{CC} for testing purposes is 36V, $V_{cc(max)}$ = 45V. Full range is -40°C to +125°C.

Typical Characteristics

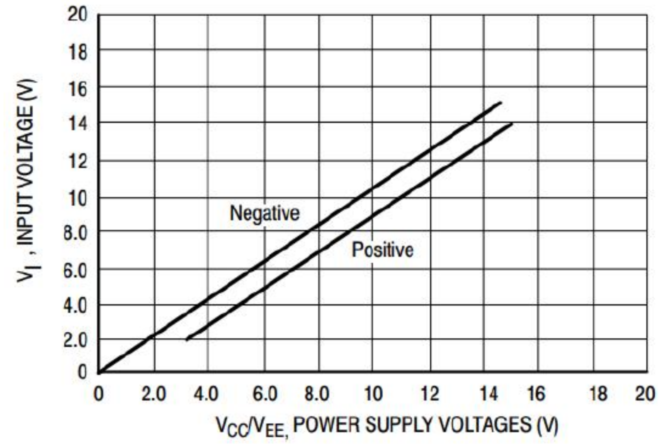


Fig1 Input Voltage Range

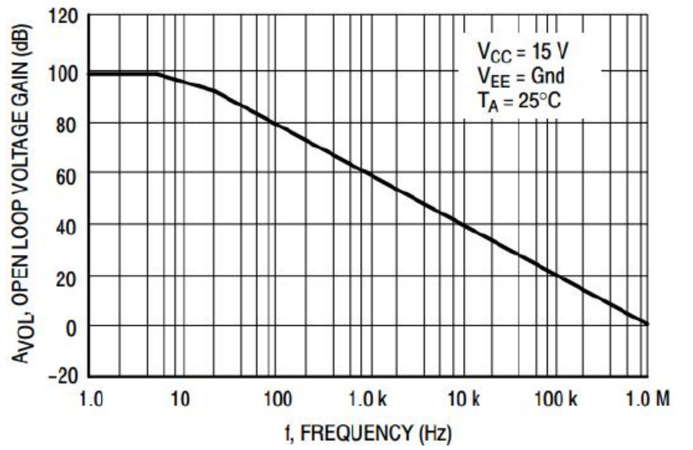


Fig2 Large Signal Open Loop Gain

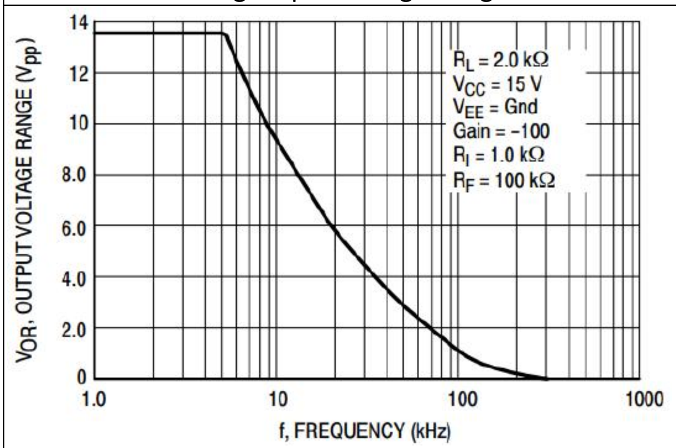


Fig3 Large Signal Frequency Response

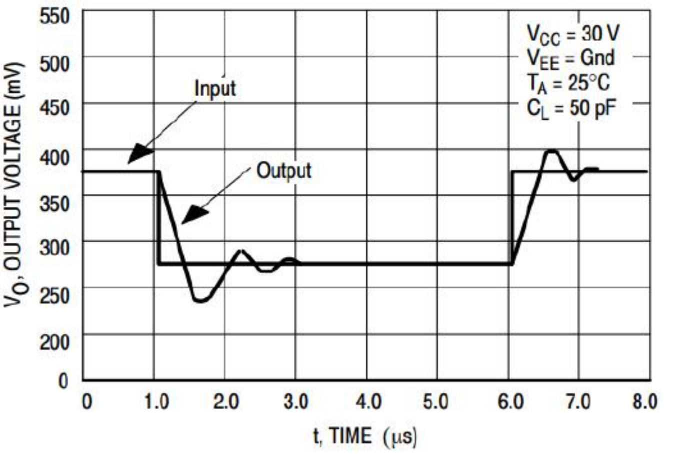
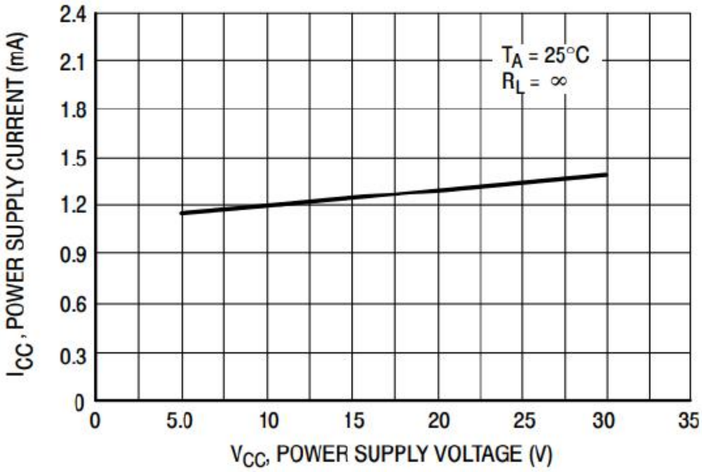
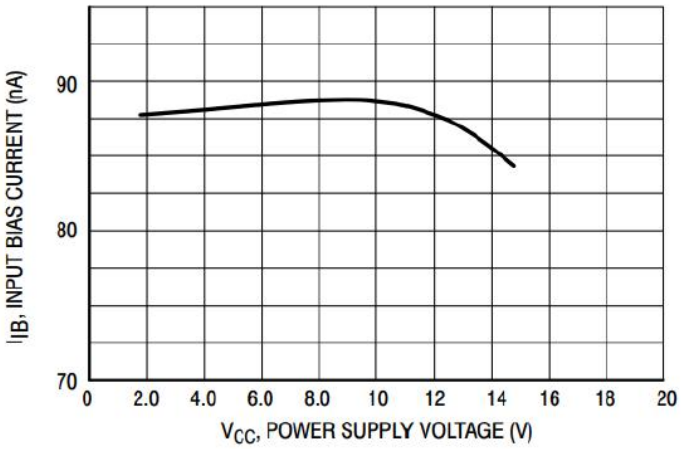


Fig4 Small Signal Voltage Follower Pulse Response

 Fig5 Power Supply Current vs Voltage	 Fig6 Input Bias Current vs Supply Voltage

IC Operation Information

Overview

These devices consist of two independent, high-gain frequency-compensated operational amplifiers designed to operate from a single supply over a wide range of voltages. Operation from split supplies also is possible if the difference between the two supplies is within the supply voltage range specified in Recommended Operating Conditions and VS is at least 1.5 V more positive than the input common-mode voltage. The low supply-current drain is independent of the magnitude of the supply voltage.

Applications include transducer amplifiers, dc amplification blocks, and all the conventional operational amplifier circuits that now can be implemented more easily in single-supply-voltage systems. For example, these devices can be operated directly from the standard 5-V supply used in digital systems and easily can provide the

required interface electronics without additional ±5-V supplies.

Unity Gain Bandwidth

The unity-gain bandwidth is the frequency up to which an amplifier with a unity gain may be operated without greatly distorting the signal. These devices have a 700KHz unity-gain bandwidth.

Slew Rate

The slew rate is the rate at which an operational amplifier can change its output when there is a change on the input. These devices have a 0.7-V/µs slew rate.

Input Common Mode Range

The valid common-mode range is from device ground to V_S – 1.5 V (V_S – 2 V across temperature). Inputs may exceed V_S up to the maximum V_S without device damage. At least one input must be in the valid input common-mode range for the output to be the correct phase. If both inputs exceed the valid range, then the output phase is undefined. If either input more than 0.3 V below GND then input current should be limited to 1 mA and the output phase is undefined.

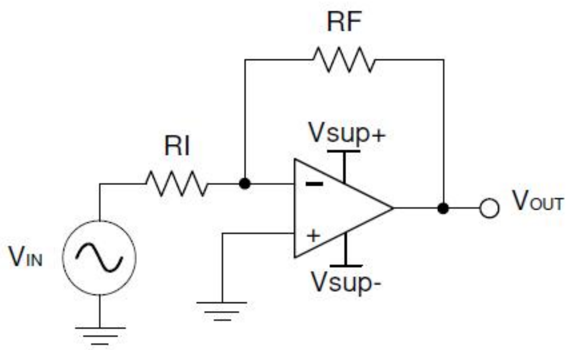
Device Functional Modes

These devices are powered on when the supply is connected. This device can be operated as a single-supply operational amplifier or dual-supply amplifier, depending on the application.

IC Application Information

The LM358 operational amplifiers are useful in a wide range of signal conditioning applications. Inputs can be powered before V_S for flexibility in multiple supply circuits. A typical application for an operational amplifier is an inverting amplifier. This amplifier takes a positive voltage on the input, and makes it a negative voltage of the same magnitude. In the same manner, it also makes negative voltages positive.

The supply voltage must be chosen such that it is larger than the input voltage range and output range. For instance, this application scales a signal of ±0.5 V to ±1.8 V. Setting the supply at ±12 V is sufficient to accommodate this application.



Power Supply Recommendations

Place 0.1-µF bypass capacitors close to the power-supply pins to reduce errors coupling in from noisy or high-impedance power supplies.

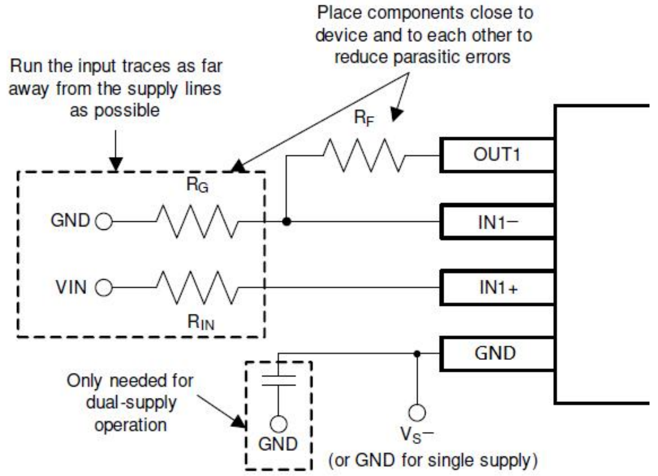
Layout Guidelines

For best operational performance of the device, use good PCB layout practices, including:

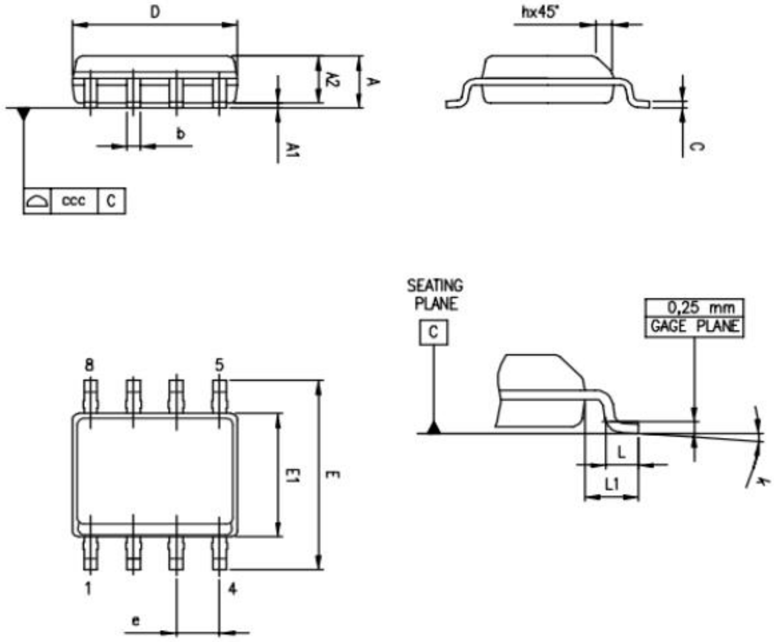
- Noise can propagate into analog circuitry through the power pins of the circuit as a whole, as well as the operational amplifier. Bypass capacitors are used to reduce the coupled noise by providing low-impedance power sources local to the analog circuitry.

– Connect low-ESR, 0.1-µF ceramic bypass capacitors between each supply pin and ground, placed as close to the device as possible. A single bypass capacitor from V+ to ground is applicable for single supply applications.

- Separate grounding for analog and digital portions of circuitry is one of the simplest and most-effective methods of noise suppression. One or more layers on multilayer PCBs are usually devoted to ground planes. A ground plane helps distribute heat and reduces EMI noise pickup. Make sure to physically separate digital and analog grounds, paying attention to the flow of the ground current.
- To reduce parasitic coupling, run the input traces as far away from the supply or output traces as possible. If it is not possible to keep them separate, it is much better to cross the sensitive trace perpendicular as opposed to in parallel with the noisy trace.
- Place the external components as close to the device as possible. Keeping RF and RG close to the inverting input minimizes parasitic capacitance, as shown in Layout Examples.
- Keep the length of input traces as short as possible. Always remember that the input traces are the most sensitive part of the circuit.
- 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.

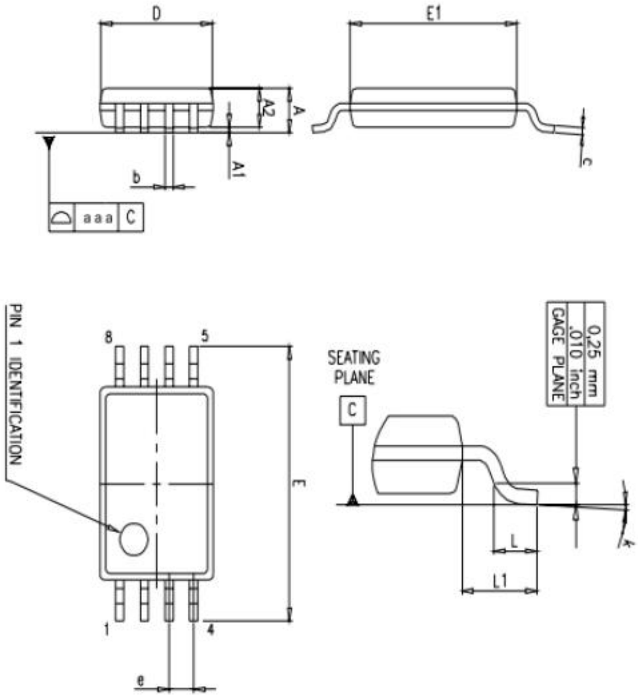


Package Information
SOP8



Ref.	Dimensions					
	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max
A			1.75			0.069
A1	0.10		0.25	0.004		0.010
A2	1.25			0.049		
b	0.28		0.48	0.011		0.019
c	0.17		0.23	0.007		0.010
D	4.80	4.90	5.00	0.189	0.193	0.197
E	5.80	6.00	6.20	0.228	0.236	0.244
E1	3.80	3.90	4.00	0.150	0.154	0.157
e		1.27			0.050	
h	0.25		0.50	0.010		0.020
L	0.40		1.27	0.016		0.050
L1		1.04			0.040	
k	0°		8°	0°		8°
ccc			0.10			0.004

Package Information
TSSOP8



Ref.	Dimensions					
	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.2			0.047
A1	0.05		0.15	0.002		0.006
A2	0.80	1.00	1.05	0.031	0.039	0.041
b	0.19		0.30	0.007		0.012
c	0.09		0.20	0.004		0.008
D	2.90	3.00	3.10	0.114	0.118	0.122
E	6.20	6.40	6.60	0.244	0.252	0.260
E1	4.30	4.40	4.50	0.169	0.173	0.177
e		0.65			0.0256	
k	0°		8°	0°		8°
L	0.45	0.60	0.75	0.018	0.024	0.030
L1		1			0.039	
aaa		0.1			0.004	